General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Produced by the NASA Center for Aerospace Information (CASI)

Econ
INCORPORATED

NASA-CR-176337
E86-10008

0008 NASA-CR-176337)
CIALIZATION OF THE LAND REMOTE SENSING N86-14710
AN EXAMINATION OF MECHANISMS AND
(ECON, Inc.) 146 p HC A07/MF A01
Unclas
CSCL 05A G3/43 00008

NASW-3339

COMMERCIALIZATION OF THE LAND REMOTE SENSING SYSTEM: AN EXAMINATION OF MECHANISMS & ISSUES

NOV 1985

82-175

ECON INCORPORATED

COMMERCIALIZATION OF THE LAND REMOTE SENSING SYSTEM: AN EXAMINATION OF MECHANISMS & ISSUES

Prepared for

U.S. Department of Commerce

Under Contract No.
NA-83-SAC-00658

Prepared by

ECON, Inc.
900 State Road
Princeton, NJ 08540

April 1, 1983

ABSTRACT

In September 1982 the Secretary of Commerce was authorized (by Title II of H.R. 5890 of the 97th Congress) to plan and provide for the management and operation of the civil land remote sensing satellite system, to provide for user fees, and to plan for the transfer of the ownership and operation of future civil operational land remote sensing satellite systems to the private sector. As part of the planning for transfer, a number of approaches were to be compared including wholly private ownership and operation of the system by an entity competitively selected, mixed government/private ownership and operation, and a legislatively-chartered privately-owned corporation.

This report presents the results of an analysis and comparison of a limited number of financial and organizational approaches for either transfer of the ownership and operation of the civil operational land remote sensing program to the private sector or government retention. The following basic approaches were considered.

- Continued ownership and operation by the federal government (planned phase-out)
- Continued ownership and operation by the federal government (establishment of necessary budget line items to continue provision of the data services)
- Wholly private ownership and operation of an entity competitively selected
- Phased private ownership (government ownership and operation with private sector marketing)
- Legislatively-chartered, privately-owned corporation.

Each of these scenarios was developed based upon the same demand forecasts and the same schedule of events. Government net cash flows were developed in all cases. For the private sector scenarios, financially viable business ventures were developed based upon achieving return on capital and other financial measures deemed necessary to achieve financing. The required rates of return were obtained through the use of government subsidies. For each scenario a complete set of financial plans was developed. Nonfinancial issues were identified in general and specifically related to each scenario.

Econ

ACKNOWLEDGEMENTS

The principal contributors to this study and authors of this report were Mr. J. Kevin Cauley, Ms. Carole Gaelick, Mr. Joel S. Greenberg, Dr. John Logsdon and Ms. Tracie Monk. They were assisted by Mr. B.P. Miller and a group of capital market consultants including Mr. Madison Haythe, William Sword & Co., Dr. Adrian Stear, Consultant, and Mr. Jerome Simonoff, Citicorp. The study was managed by Mr. Joel S. Greenberg.

During the course of this study many individuals and organizations were contacted, and provided valuable assistance without which this study could not have been accomplished. Among these were the National Oceanographic & Atmospheric Administration (NOAA); National Environmental Satellite, Data and Information Service (NESDIS); National Aeronautics & Space Administration (NASA), both Headquarters and Goddard Space Flight Center; U.S. Department of Agriculture (USDA), both the Foreign Agriculture Service and the Statistical Reporting Service; the Central Intelligence Agency; the Department of Interior (DOI), including the Bureau of Land Management, the U.S. Geological Survey and the Earth Resources Observation System Data Center; U.S. Foreign Service; Congressional Research Service; Communications Satellite Corp.; Spot Image; RCA; General Electric; American Science and Technology Corp.; GeoSat; Metrics; Lockheed; Hughes and Terra-Mar.

This study was performed under the direction of Mr. W. Eskite, NOAA.

Joel S. Greenberg
Vice President

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

ECON

LIST OF FIGURES

LIST OF FIGURES
(Continued)

LIST OF FIGURES
(Continued)

LIST OF TABLES

I. INTRODUCTION

For more than a decade, and at a cost estimated to be in excess of $1.5 billion, the U.S. government has conducted research, development and demonstration of land remote sensing technology. These programs have now progressed to the point where data is being obtained on a continuous basis from a land observation satellite (LANDSAT D) and information products are provided to and utilized by government, industry and foreign organizations. During the past few years attention has increasingly focused on the operational nature of the LANDSAT system which includes a space data collection segment and a ground processing and information dissemination segment. The federal government, realizing the operational nature of the system designated, in November 1979 the National Oceanographic and Atmospheric Administration (NOAA) to manage the LANDSAT system. NOAA was selected as the operating agency because of its experience in managing and operating the National Environmental Satellite System which has involved 24 environmental satellites since 1966 [1].

As the land observation satellite system continued to evolve, attention has focused on the appropriate public sector and private sector roles [2-20]. In keeping with this, in September 1982 the Secretary of Commerce was authorized to plan and provide for the management and operation of the civil land remote sensing satellite system, including the LANDSAT D and D' satellites and associated ground system equipment transferred from NASA; to provide for user fees; and to plan for the transfer of the ownership and operation of future civil operational land remote sensing satellite systems by the private sector, when in the national interest [10]. As part of this planning for the transfer of the ownership and operation of civil operational land remote sensing satellite systems to the private sector, the Secretary was requested to:

A. Conduct a study to define the needs of the government for land remote sensing data

B. Determine and describe the equipment, software and data inventory susceptible to transfer to the private sector

C. Compare various feasible financial and organizational approaches for such a transition.

Criteria for the comparison was to include considerations such as: maintenance of data continuity; maintenance of U.S. leadership; national security; international

obligations; potential for market growth; cost to the government; independence of subsidy or financial guarantee from the government; potential of financial return to the government and price of data to users. The following approaches were to be compared: 1) Wholly private ownership and operation of the system by an entity competitively selected; 2) mixed government/private ownership and operation; and 3) a legislatively-chartered, privately-owned corporation.

In addition to the above studies and comparisons, the Secretary was asked to fund at least two parallel studies outside the government so as to independently conduct the comparisons called for above. ECON, Inc. was selected early in January 1983 as one of the contractors to perform these studies. The results of this work are reported herein.

The specific objective of the study was to provide an analysis and comparison of a limited number of financial and organizational approaches for either transfer of the ownership and operation of the civil operational land remote sensing program to the private sector or government retention. The following basic approaches for commercialization or retention were considered:

- Continued ownership and operation by the federal government (planned phase-out)
- Continued ownership and operation by the federal government (establishment of necessary budget line items to continue provision of the data services)
- Wholly private ownership and operation of an entity competitively selected
- Phased private ownership (government ownership and operation with private sector marketing)
- Legislatively-chartered, privately-owned corporation.

We have taken the position that in order to evaluate the alternatives it is necessary to plan potential business ventures and evaluate their financial merit, the likelihood of their financing and their impact on government cash flows. We have tried to play the role of an entrepreneur, putting together business plans for the purpose of obtaining financing. The business plans are based upon a perceived technology base and a market forecast. The market forecasts are felt to be reasonably conservative because of the selected role (as entrepreneur). It is obvious that many business scenarios may be developed, ranging from flying an instrument in the Space Shuttle and selling resulting images, to the Communications Satellite Corporation's proposal to acquire and operate a combined land observation and meteorological satellite system. Due to the very finite nature of

this study, a specific business system was defined (Section 3) and used as the common basis for analyzing the various approaches for commercialization or retention of the land remote sensing system. It must be emphasized that this system has not been optimized either from the point of view of private sector profit maximization or public sector benefit maximization. It appears to be a reasonable possibility with its main virtue being the introduction of commonality which facilitates comparison between all of the approaches analyzed.

It should be noted that the selected business system does not include "value added" functions. It was not possible within the scope of the current effort to obtain sufficient information to allow the planning of value added business ventures.

Figure 1.1 presents an overview of the study approach. The first step was the development of the financial and organizational options of interest. In order to compare these options or scenarios, a common business scenario was defined. This included a schedule of events, data flows and other important features. This is described in Section 3, The Business Scenario. Section 2 presents, as general background, a description of the current land observation system upon which the business system builds. A demand forecast was made based upon a review of the published literature and discussions with current and potential user groups and competitive suppliers of information products. The demand forecasts and projected revenues are described in Section 4, The Marketplace. These forecasts and projections were held constant across all scenarios. Cost estimates were based upon detailed data obtained from the current operating entities and are described, as appropriate, in Section 6.1 through 6.4. Detailed schedules in support of the specific cost items are presented in appendices.

The demand forecasts and the cost estimates together with other information such as recoupment, leasing and subsidy policies and desired return on capital served as input to the financial analyses. The financial analyses developed the pro forma income statements, cash flow statements and balance sheets for a ten-year planning period. The financial analyses were performed for each of the scenarios of interest. The specific scenarios are described in Section 5 and the financial analyses are described in Section 6. The financial analyses were used as input to a government cash flow analysis—this is also discussed in Section 6.

The results of the financial analyses were reviewed by a group of individuals with expertise in the capital markets. The review established financial criteria

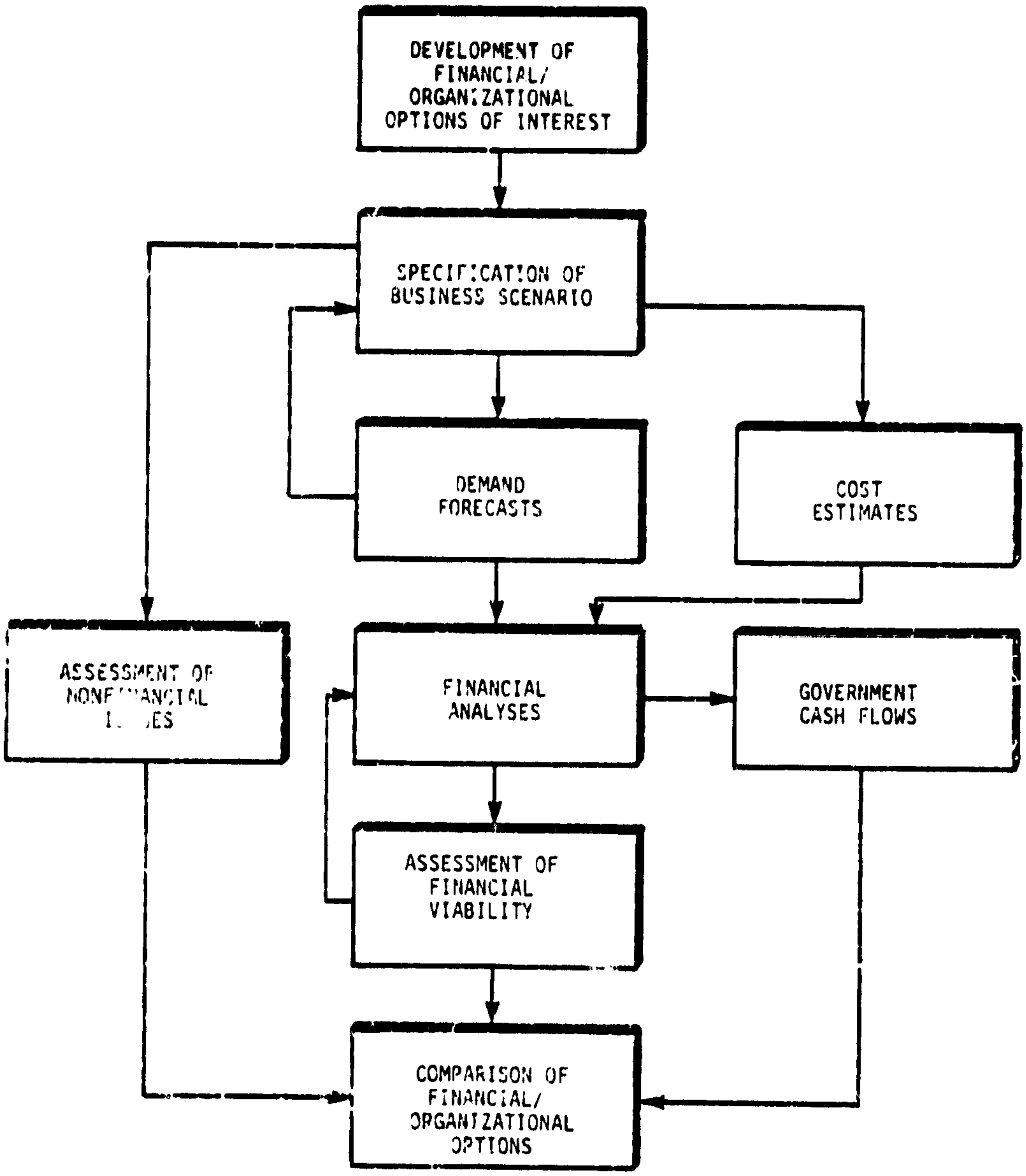


FIGURE 1.1 OVERVIEW OF STUDY APPROACH

that must be met in order to have a viable business venture—i.e., attract investment funds from capital markets. These criteria are described in Section 6 as well as the general procedure used in the financial analyses.

In parallel with, and at times providing guidance to the financial analyses, an assessment of nonfinancial issues was performed. These included political, institutional, legal/regulatory, international, national security and policy issues. These are discussed in Section 7 with emphasis placed on differences in their effects upon the different scenarios. The objective of considering these issues was to establish policy, legislative and organizational requirements that are deemed necessary for each of the scenarios to be viable.

General and specific observations and conclusions are presented in Section 8 and recommendations are presented in Section 9.

The data utilized in this study was obtained from the indicated referenced documents and from discussions with individuals in government agencies and commercial organizations. These included the National Oceanographic & Atmospheric Administration; National Aeronautics & Space Administration; U.S. Department of Agriculture, both the Foreign Agriculture Service and the Statistical Reporting Service; the Central Intelligence Agency; the Department of Interior, including the Bureau of Land Management, the U.S. Geological Survey and the Earth Resources Observation System Data Center; U.S. Foreign Service; Communications Satellite Corp.; Spot Image; RCA; General Electric; American Science and Technology Corp.; GeoSat; Metrics; Lockheed; Hughes and Terra-Mar. Due to time constraints this data could not be independently validated or estimated. The fact that this data is used in the study reported herein should not be interpreted to mean that these estimates are considered to be valid.

2. THE CURRENT LAND OBSERVATION SYSTEM

Remote sensing implies the detection of the nature or condition of an object without touching it. The advent of first the photographic camera and later the airplane represented major advances in remote sensing. Space remote sensing was first tried experimentally when cameras were used on manned orbital flights to take multispectral photographs of the Earth. Later, in 1973, Skylab was outfitted with sensors designed to the specifications of the Departments of the Interior and Agriculture, which used the data in programs that tested possible applications in planning, management and resource conservation [21].

The LANDSAT program began in July 1972 when the first LANDSAT satellite (the Earth Resources Technology Satellite-1) was launched by NASA. The program began as a research and development effort to determine the usefulness of satellite multispectral information, provided as synoptic views of the Earth's surface [22]. In the ten years that followed three more LANDSAT satellites were launched so that a continuous flow of information about the earth's surface was transmitted over an extended period of time. LANDSAT data has been used regularly in a wide range of applications from crop forecasting to mapping, to land use planning and resource management. The program has developed into a valuable source of information for agricultural and urban planning, geologic exploration, land management studies, snow melt and flood runoff analysis, crop stress location and other tasks requiring large-scale views of the Earth's surface areas.

LANDSAT D (LANDSAT 4) was launched July 16, 1982 into a polar orbit at an altitude of 705 kilometers. It circles the Earth every 98.9 minutes and images the same 185 kilometer swath of the Earth's surface every 16 days. A follow-on satellite, LANDSAT D', is available to replace or supplement LANDSAT D.

The LANDSAT data collection system consists of the LANDSAT D satellite in orbit, the LANDSAT D' satellite currently in storage, a communications satellite system, ground receiving stations, a ground data processing and satellite control facility, and a data distribution center.

2.1 LANDSAT D and D' Satellites

LANDSAT D (and D') illustrated in Figure 2.1, consists of the Standard Multi-Mission Modular Spacecraft and a mission unique instrument module. The spacecraft, which is compatible with Space Shuttle launch and retrieval, contains the

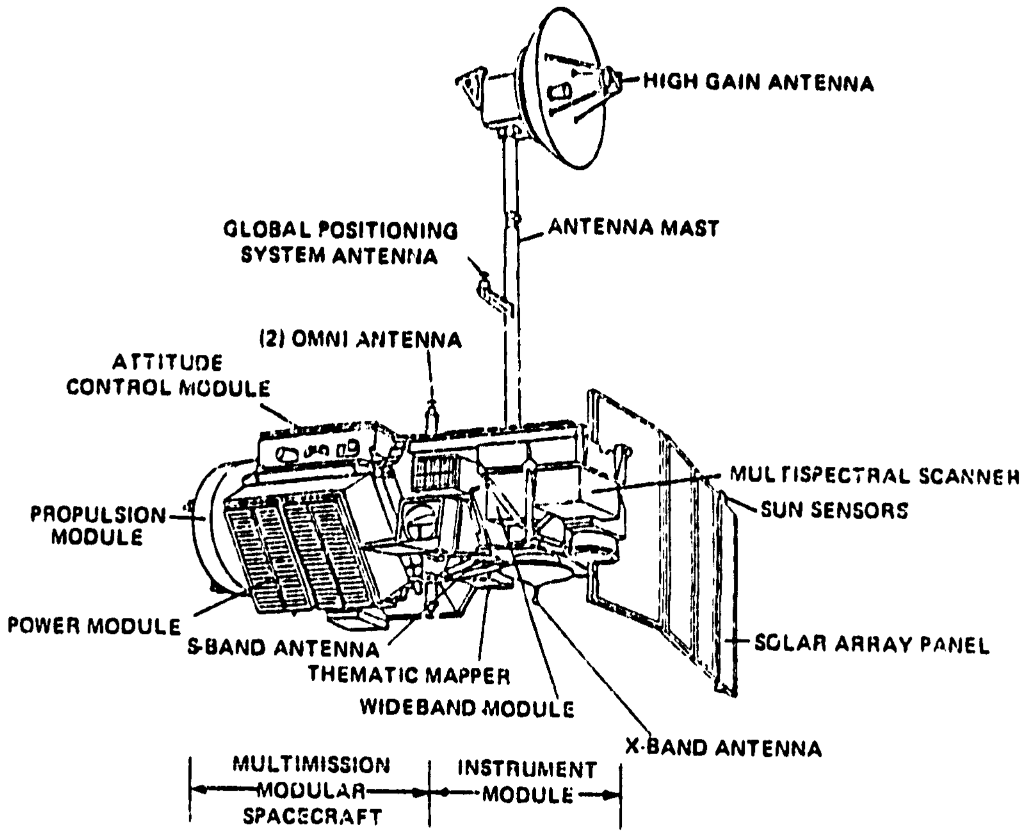


FIGURE 2.1 LANDSAT D FLIGHT SEGMENT

attitude control, communications, data handling and power subsystems. Included in the instrument module are the Multi-Spectral Scanner (MSS), Thematic Mapper (TM), a wideband communications subsystem, high-gain and other antennas, and a solar array that can generate two kilowatts of power. The MSS is a radiometer, an instrument that collects and measures energy reflected or emitted in discrete intervals of the electromagnetic spectrum. It has four spectral bands in the visible and near infrared portions of the spectrum and has an 80 meter spatial resolution. The TM works like the MSS but is a seven band multispectral, high resolution scanner with 30 meter spatial resolution [20].

2.2 Communications System

Until the launch of NASA's Tracking Data Relay Satellite System (TDRSS), data coming directly from LANDSAT D will be received by ground receiving stations located in the U.S. and 11 foreign countries. Coverage is limited by receiving station line-of-sight, since LANDSAT D has no on-board recording capability. The U.S. has arranged to receive foreign scenes by mail from these

stations albeit sometimes with long delays. Once TDRSS is in operation it will receive data from LANDSAT and transmit it to a ground receiving station at White Sands, New Mexico. This location was selected to minimize propagation effects on the TDRSS down-link. The positioning of the satellites in the TDRS system (one at 41°W and one at 171°W longitude) will allow for data acquisition from nearly all of the earth's surface. Foreign ground stations will continue to collect data for their own use directly from the satellite and can obtain other scenes from the U.S. facility at Sioux Falls.

Data received at White Sands is demodulated, separated and recorded on separate wideband data recorders. Compacted raw data tapes are prepared and transmitted via a domestic communications satellite (hereinafter referred to as DOMSAT) from White Sands to the processing facilities located at Goddard Space Flight Center in Greenbelt, Maryland with, under normal conditions, a data delay of no more than eight hours from sensor observation to availability for processing at GSFC. In the case of a DOMSAT failure of greater than two days, the raw data tapes will be mailed from White Sands to GSFC [23]. Once MSS data is processed at GSFC it is sent through DOMSAT to the EROS Data Center (EDC) at Sioux Falls, South Dakota.

The TDRSS and DOMSAT communications satellite systems will substantially reduce time delays that have been encountered in shipping data from foreign ground stations to the U.S. and from LANDSAT ground receiving stations to Goddard Space Flight Center, and subsequently to EDC.

2.3 Ground Segment

Raw data is received at GSFC, is stored on high density tapes (HDT_R) and sent to the Image Generation Facility for preprocessing, framing, radiometric correction and computation of geometric correction matrices, to produce a high density archival tape (HDT_A), in the case of MSS data. TM data is processed further, into computer compatible tapes and film [24]. Separate (computer) processing strings exist for MSS and TM processing.

User requests for data acquisition over specific land areas are input into the system through a mission management facility which sends such requests to the Control and Simulation Facility for spacecraft orbital operation planning and scheduling [24]. A basic data set is routinely acquired, but a user may make a request for "special acquisition data" (for which there is a fee). The mission

management facility also provides image data production management, management reporting, database management, control point library generation, inventory control and ground segment management.

Control and monitoring of the spacecraft, coordination of the ground schedules with the spacecraft, performance analysis and mission planning are handled by the Control and Simulation Facility [23].

Evaluation of the image data, with emphasis on assessing systems handling TM data, is conducted by the LANDSAT Assessment System [23]. Figure 2.2 illustrates the flow of information in the ground segment.

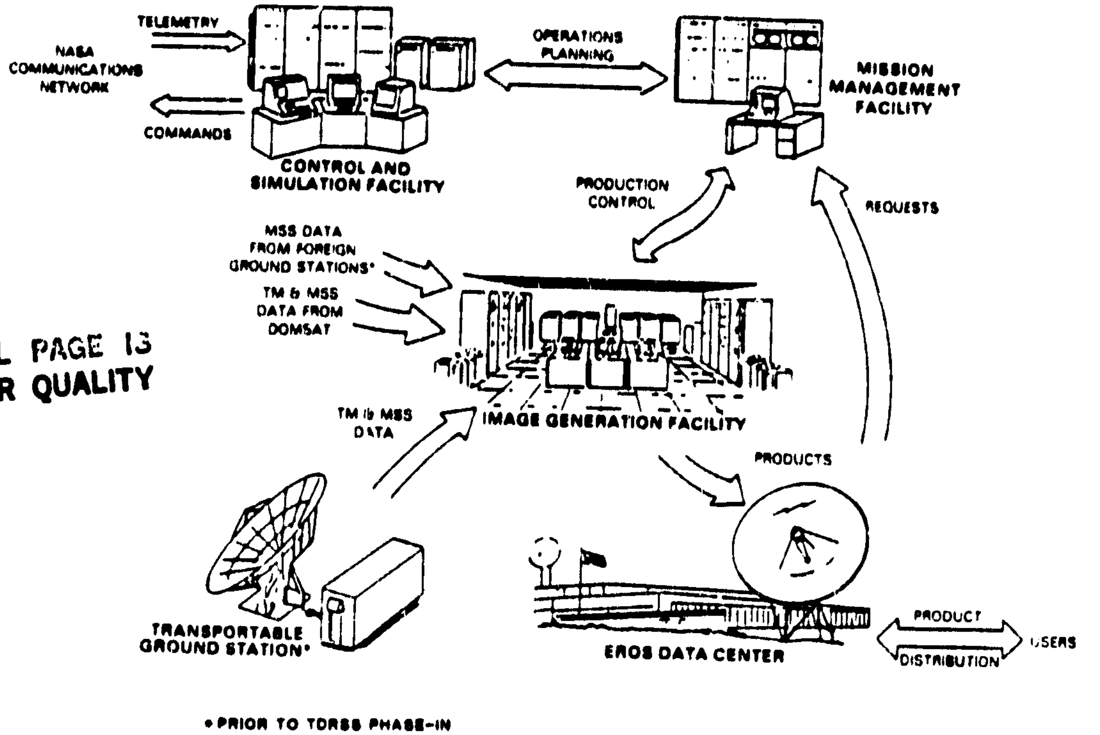
2.4 Data Distribution Center (EDC)

MSS data on high density archival tapes are relayed from GSFC through DOMSAT to the EROS data Center (EDC) located in Sioux Falls, South Dakota. At EDC the incoming data is recorded on high density tape, which is sent through the EROS Digital Image Processing System to ascertain readability, correct geometry and generate black and white 241 mm latent film. The film is processed into a film master and the HDT and film master are archived. When scenes are ordered, digital products will be generated from the HDT and film products from the film master [25].

Goddard-produced TM film will be inspected for quality and cloud cover and a working master generated and stored in the archives. TM digital data (on CCTs) will be inspected for physical defects [25]. Products will be produced from the film master or CCT to fill customer's orders.

The Center's computer complex controls a database of over six million images and photographs of the Earth's surface features [20].

Figure 2.3 illustrates the flow of information in the total LANDSAT system.



ORIGINAL PAGE IS
OF POOR QUALITY

FIGURE 2.2 LANDSAT D GROUND SEGMENT
(SOURCE: LANDSAT D MISSION SYSTEM INDUSTRY BRIEFING, FEBRUARY 26, 1982)

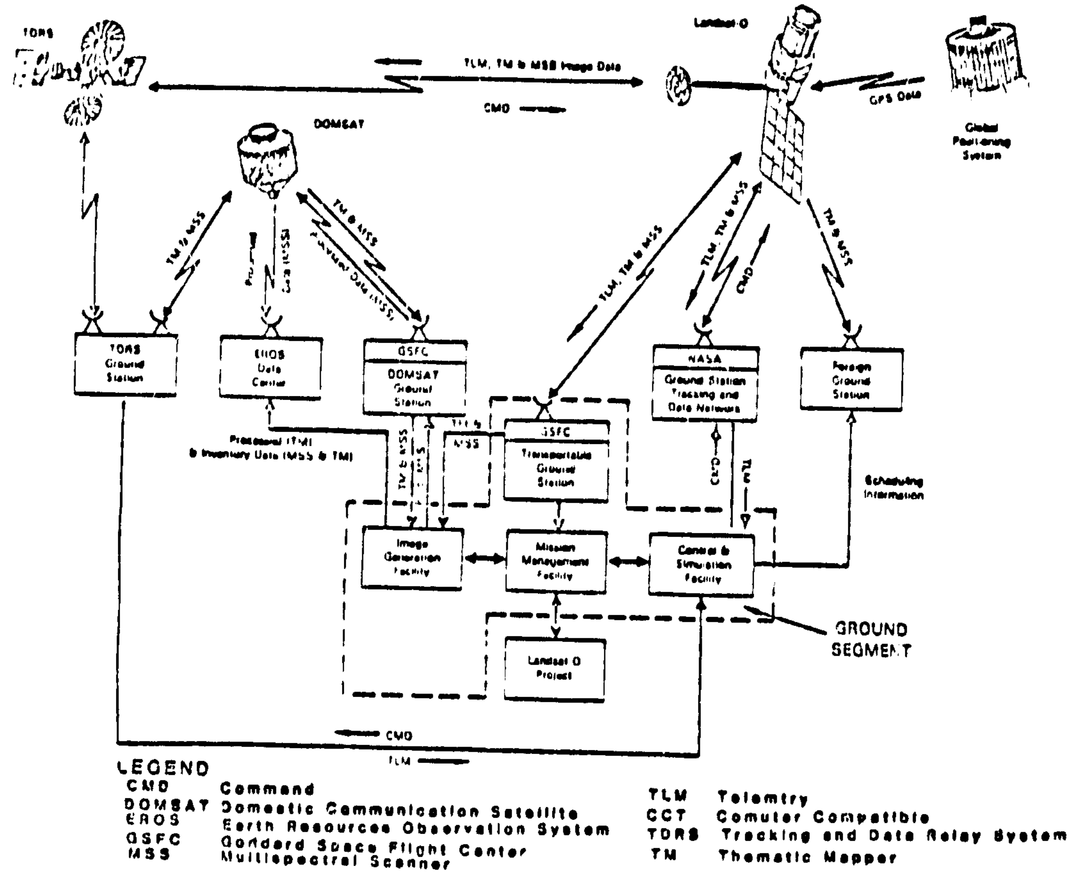


FIGURE 2.3 LANDSAT D SYSTEM OVERVIEW
(SOURCE: LANDSAT D MISSION SYSTEM INDUSTRY BRIEFING, FEBRUARY 26, 1982)

3. THE BUSINESS SCENARIO

Underlying the analysis and comparison of the financial and organizational approaches for either transfer of the ownership and operation of the civil land remote sensing program to the private sector or government retention is a basic commonality. This commonality is with respect to the level of service provided in the marketplace and hence product sales. Thus a point of departure is a set of products having the same attributes (including price, resolution, timeliness, etc.) over time for each of the scenarios. The result is a demand forecast that is independent of scenario, a timeline or schedule of events that is independent of scenario, and a basic business concept that is independent of scenario. With these factors constant from scenario to scenario, attention can be focused on the relative attractiveness of scenarios, their affect on government cash flows, the impact of recoupment policies and other factors.

The anticipated schedule of events that is a major factor driving the costs of all the business scenarios is illustrated in Figure 3.1. For reasons to be discussed subsequently, it is assumed that commercial operation will commence at the start of fiscal year 1985. If this date is delayed, continuity of service will be jeopardized unless the federal government initiates procurement of another backup satellite (in addition to D'). A number of specific events and their timing (fiscal year) is shown. LANDSAT D was launched in FY82. It has already run into problems which have necessitated operations on backup subsystems. It is assumed that the multi-spectral scanner (MSS), having 80 meter resolution, will fail at the end of FY85 and the thematic mapper (TM), having 30 meter resolution, will fail at the end of FY84. It should be noted that specific failure dates have been assumed for events that are basically random in nature. It is assumed that the MSS is the primary sensor and that LANDSAT D' will be launched during FY85 in anticipation of an MSS failure. It is felt that this (launch on anticipation) is important to demonstrate the intention of continuity of service to potential users of the information products. LANDSAT D' also has an MSS and a TM. It is assumed that this TM will fail after approximately two years of service and that the MSS is placed into an in-orbit spare status at about the same time.

Immediately upon commercialization it is assumed that two LANDSAT Es will be procured. LANDSAT E will consist of the same "bus" used in LANDSAT D

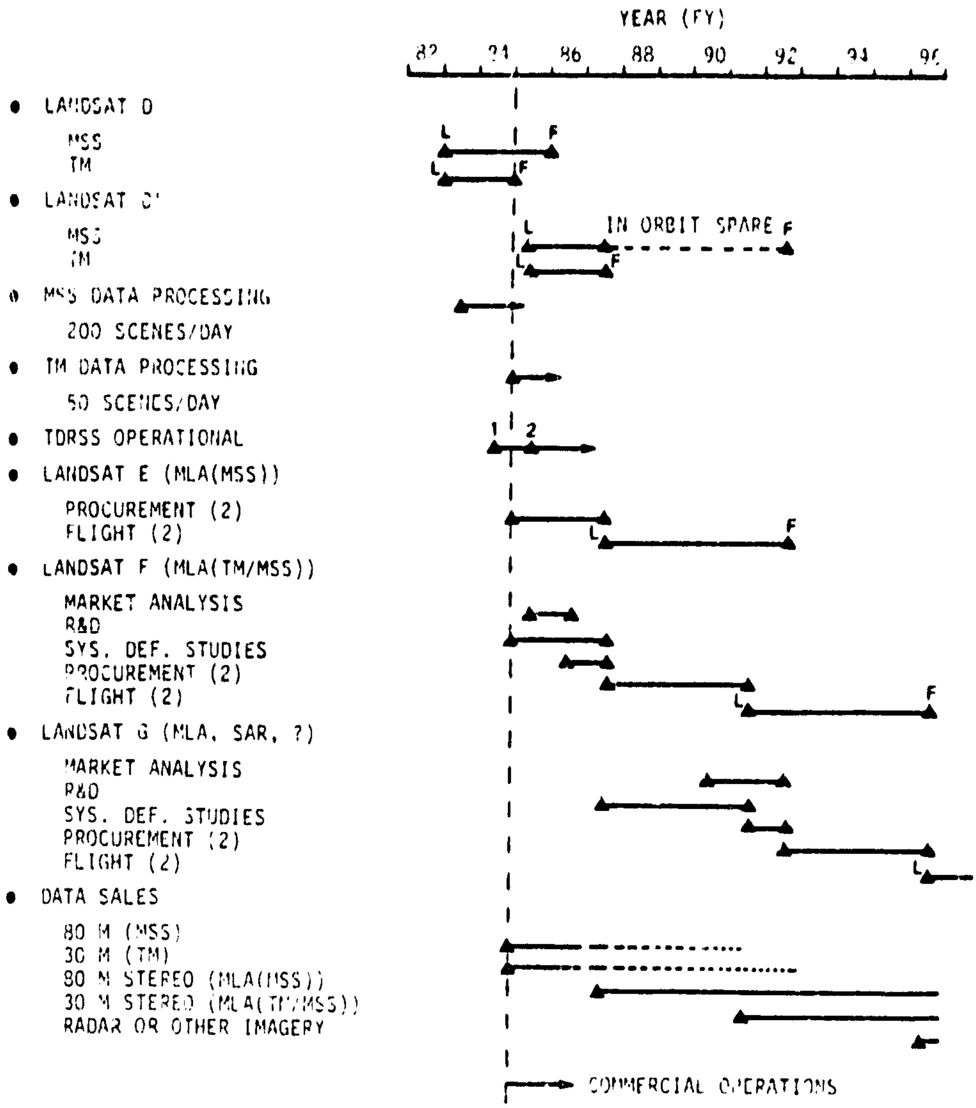


FIGURE 3.1 LAND OBSERVATION SYSTEM--ANTICIPATED SCHEDULE OF EVENTS

and LANDSAT D' (the Multi-Mission Spacecraft), plus a solid state version of the MSS—a multi-linear array having a stereo capability. The stereo capability allows the observation of scenes at different angles from the nominal ground track. This procurement must proceed with haste since in the absence of LANDSAT E there is no spare for the MSS on LANDSAT D' and continuity of service is in jeopardy. Continuity of service is deemed extremely important since, as will be discussed, the large part of the demand for information products is associated with renewable resources which require up-to-date information. Two spacecraft are procured in order to have a reasonable chance for the desired continuity of service. The 80 meter resolution MLA is indicated because time is of the essence, and the development of a 30 meter resolution MLA would require an extended development schedule. It is anticipated that the two LANDSAT E spacecraft together with the LANDSAT D' MSS on-orbit spare will provide service through FY92.*

During FY91 LANDSAT F, having a solid state version (multi-linear array) of the TM with 30 meter resolution, will be launched. It is assumed that the decision to develop LANDSAT F will be based upon a market analysis and that two spacecraft will be procured. These will last through the remainder of the planning horizon. Since it is likely that additional spacecraft will be required in the latter part of the 1990s, expenditures for their development and procurement (LANDSAT G) will be required during the planning horizon.

As will be discussed in Section 4, there is a need for both 80 meter and 30 meter resolution information products. LANDSAT F will have a 30 meter resolution capability. To satisfy both the 30 and 80 meter product needs, the 30 meter data will be degraded to produce 80 meter products as necessary. This will allow attribute pricing policies to continue and to provide the lower priced products required by the renewable resource community.

The basic concept of the land remote sensing business system is shown in Figure 3.2. It is assumed that the government will continue to perform R&D related to the development of sensors and associated technologies and new information extraction techniques. The results of this R&D will be available to the land observation venture. The land observation venture will utilize the tracking data relay satellite (TDRSS) and domestic communication satellite (DOMSAT)

*The question of number of spacecraft to be procured is addressed in Appendix A and is based upon the use of a stochastic mission and life cycle cost simulation model, SATIL.

ORIGINAL PAGE IS
OF POOR QUALITY

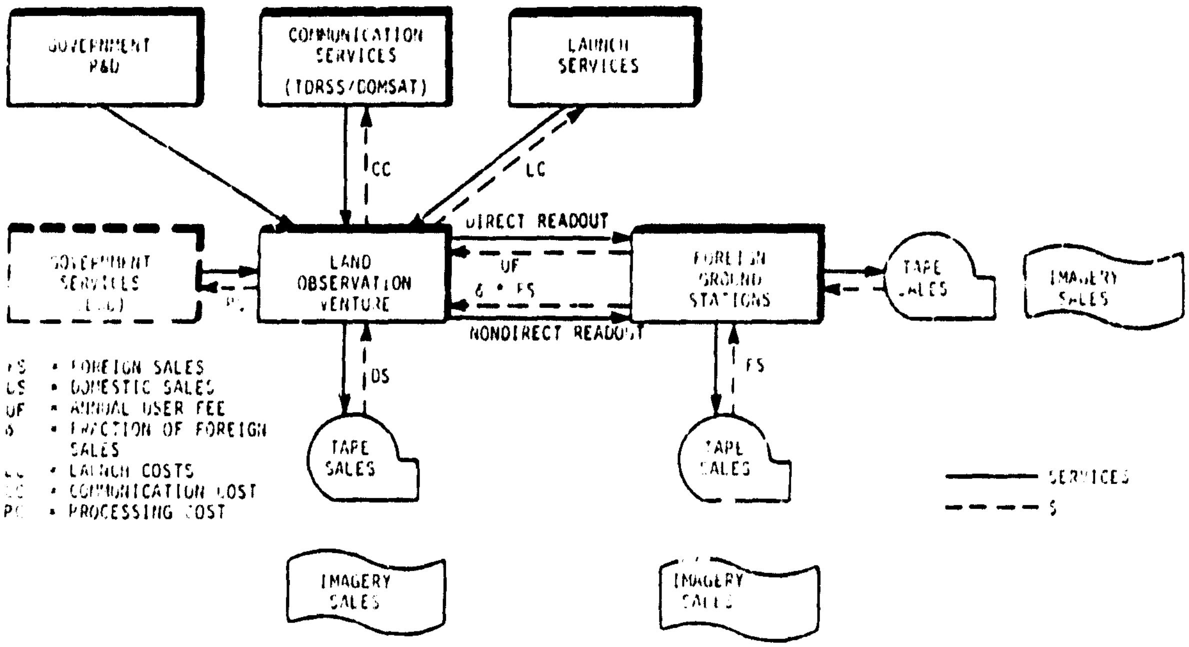


FIGURE 3.2 BASIC CONCEPT OF LAND REMOTE SENSING BUSINESS SYSTEM

services. The venture will also utilize launch services provided by either government or nongovernment operations.* It is assumed that initially the venture will utilize services (archiving and sales—not marketing) provided by the EROS Data Center which will be reimbursed for all costs incurred. The venture will, in essence, take over the Goddard Space Flight Center Data Processing Facility and the White Sands Ground Station. At an appropriate point in time, all data processing and sales facilities will be consolidated at White Sands (White Sands must remain since it was selected in order to minimize communication problems with the TDRSS).

---

*Launch services are a potential problem. The LANDSAT series is designed to be launched on a Delta vehicle. At present, NASA does not plan to have Delta vehicles available after the launch of LANDSAT D'. There are no definitive plans for commercialization of the Delta, although this is a possibility. In the absence of the Delta, there appear to be other possibilities—a West Coast Shuttle launch or the use of Ariane. Because LANDSAT series spacecraft are not optimized for Shuttle launch and the limited number of payloads to be launched from the West Coast, it is likely that the LANDSAT launch would be charged for a dedicated Shuttle flight. This would impose a significant penalty on the LANDSAT observation business venture. A new spacecraft could also be developed to reduce launch costs but development cost would be incurred. In the financial analysis considerations in Section 6 the cost of a Delta launch ($35 million--FY83$) has been assumed.

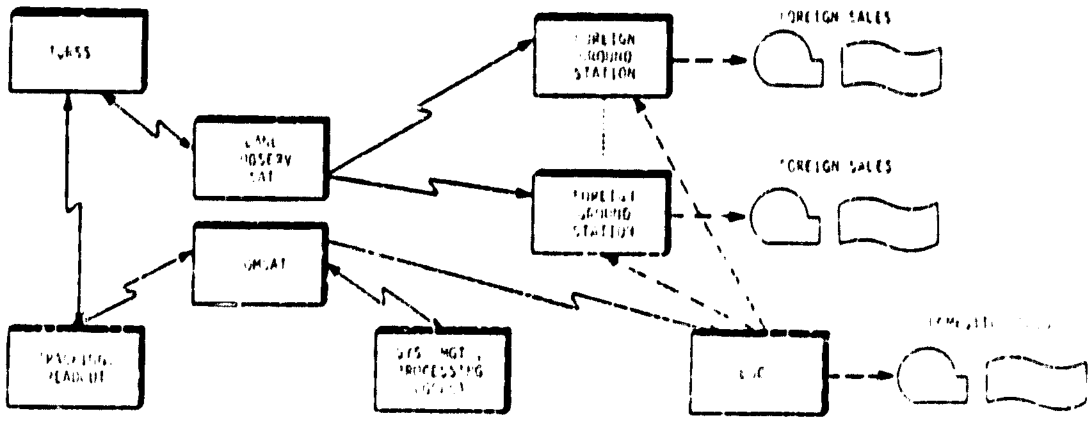
It is assumed that the foreign ground stations will be franchised, each having a region within which it is the sole supplier of information products. The foreign ground stations will continue to be able to obtain direct readout from the satellites when they are observable. Annual fees will be paid for this. Scenes so obtained can be distributed within the franchise area without restrictions. The foreign ground station will be responsible for sales in its region of information products that cannot be obtained by direct readout. Revenue from sales so obtained will be split with a portion maintained by the ground station and the remainder paid to the U.S. venture which will provide the necessary information products. The goal is to establish a foreign marketing organization using the existing ground stations as the starting point. Franchises may also be established without having a ground station.

Figure 3.3 illustrates the staged operations of the business system and the flow of information. Stage I utilizes the system configuration which will be in place in FY85. Stage II consolidates all functions at White Sands. During Stage I LANDSAT observation satellite data is transmitted via TDRSS to the tracking and readout facility at White Sands which communicates this data via DOMSAT to the system management and processing center at Goddard Space Flight Center (GSFC). Data is processed into information products at GSFC which then communictes the bulk of these products to EDC via DOMSAT. The foreign ground stations receive direct readout from the land observation satellite and also receive requested scenes from EDC.

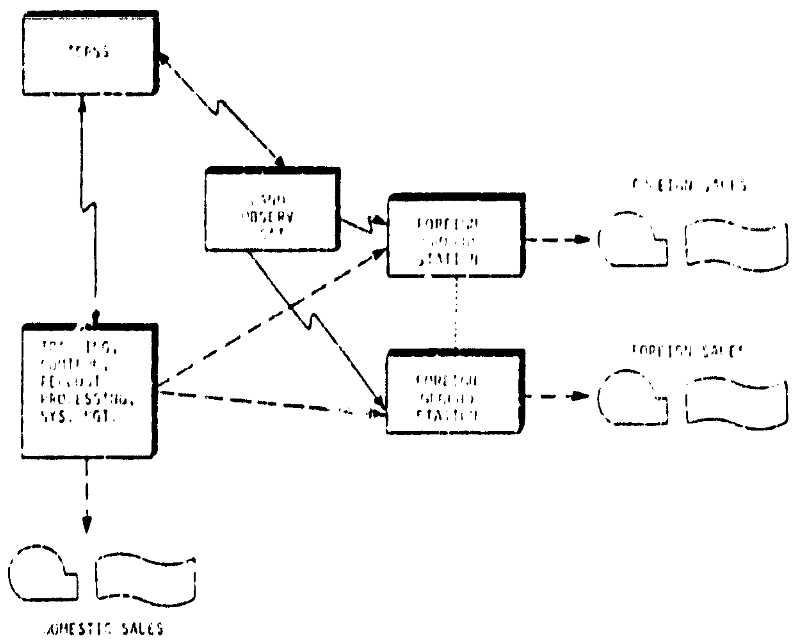
During the second stage the data processing, archiving, sales and tracking, and control facilities are consolidated at White Sands. This allows the elimination of duplication of facilities and eliminates the need for DOMSAT communications.

The previously defined events schedule and business concepts serve as the common basis for evaluating the alternative financial and organizational scenarios.

ORIGINAL PAGE IS
OF POOR QUALITY



(A) STAGE I



(B) STAGE II

FIGURE 3.3 THE BUSINESS SYSTEM: STAGED OPERATIONS

4. THE MARKETPLACE

4.1 Products

LANDSAT D provides data from two sensors, the Multi-Spectral Scanner (MSS) and the Thematic Mapper (TM), which is processed into photographic images and computer digital tapes. Each LANDSAT scene covers an area whose dimensions are 185 kilometers on each side. Data is provided from the MSS in four spectral bands with a spatial resolution of approximately 80 meters. The TM obtains data in seven spectral bands with a spatial resolution of approximately 30 meters. Customers for resulting information products may order photographic images in film and paper, positive and negative format, in black and white and color, and in sizes from 70 mm to 40 inches.* Digital products may be ordered in partially or fully corrected formats.

The basic collected data and resulting processed information products have value only to the extent that they can be interpreted and applied in decision making and planning. In the years since the Multi-Spectral Scanner has been available, techniques have been developed to utilize the information products in a wide range of applications. Information acquired through analyses of LANDSAT data has demonstrated value in crop assessments and yield forecasts, forest and range inventory and monitoring, soil analysis, surface water delineation, land cover classifications, mapping, urban planning, location of oil and mineral resources and the understanding of the composition of the Earth's surface.

The Foreign Agricultural Service, for example, uses LANDSAT data in providing information to aid U.S. farmers and traders to adjust to changes in world demand for U.S. agricultural products [2]. Maps produced with the aid of LANDSAT data are being used by the Bureau of Land Management in their management of federal land, by the Corps of Engineers in conducting dam inspections, and by several states in urban land-use delineation and hydrologic land use planning [1]. Many oil and gas companies have developed in-house computer processing capabilities for LANDSAT data interpretation to assist in their worldwide exploration activities. This latter application has probably been the largest nonfederal user of LANDSAT tapes and imagery products.

---

*A distinction is made between data products, the raw data prior to processing and information products, the processed data made available for sale in the form of imagery or digital tapes.

The increased resolution, new spectral bands, in addition to narrower bands in green, red and near infrared of the Thematic Mapper offer advantages beyond those of the Multi-Spectral Scanner and, consequently, increased value in applications. However, TM data is costlier than MSS data ($2,800 for a TM scene in tape format versus $650 for an MSS scene in tape format), and for some uses the increased content of a TM scene may not justify the higher costs.

New spectral bands will enable differentiation among a wider variety of crops, vegetation, rock and soil types than was possible with the MSS. Measurement of surface temperature will allow identification of plant health and improve identification of individual plant type, and may be used in identifying and mapping surface composition for geological studies.

Increased spatial resolution will permit more effective use of data in land use mapping and planning, storm water management and geologic mapping because features are more distinct in TM observations.

4.2 Customers

Users of information products from a land remote sensing system have different needs (based upon applications) for specific product attributes such as spatial resolution, number and location of spectral bands, frequency of observation, timeliness of delivery of information, and area of coverage. The users of the information products, depending upon applications, require information products that are packaged in different forms ranging from film to high density digital tapes. Some users require a large number of scenes on a repetitive basis (the renewable resource applications) while others require a small number of scenes on a nonrepetitive basis (the nonrenewable resource applications). The former applications generally have relatively low value per scene whereas the latter applications have relatively high value per scene.

The major user of LANDSAT data has been the federal government, although its share of total U.S. distributions of information products has declined to about 33 percent [20]. It is estimated that in FY83, $7 to $8 million will be allocated among federal agencies for LANDSAT data. Within the federal government, the largest user is the Department of Argiculture with a budget estimated to be slightly in excess of $3.5 million in FY83 for data acquired over foreign areas and $150,000 on domestic data. For the Foreign Agricultural Service, LANDSAT is the only way to obtain global crop information. In domestic crop monitoring,

alternative means do exist for collecting data. Aerial photography, district rangers, county agents and extension workers are used regularly, especially during the growing seasons. Because of anticipted budget constraints coupled with the agencies use of large quantities of LANDSAT data, it is not likely to shift to the use of the more expensive TM data on a significant scale. Timeliness of delivery and frequent observations are critical to the value of the data. Based upon previous benefit estimates [26-29] it appears that USDA budgets* for information products bear little or no relationship to the potential benefits.

Among the other federal government users are the CIA, Department of Interior, DOD and NASA. It is estimated that their combined FY83 expenditures for information products will be of the same order as the USDA's. The information products will be used for both renewable and nonrenewable resource management applications.

State and local government users constitute a small segment of the market; about 5 percent of the nonfederal market [20]. They are low volume users. Many states have developed internal data analysis capabilities [7]. The largest number of state applications have been in environmental management, forest/rangeland management, and water resources planning and management [12]. Higher resolution images over urban and suburban areas are valuable to urban planners concerned with changing land use patterns [30].

Academic institutions use LANDSAT data in research or teaching. Some purchase data to perform value added services for state and local government organizations or other clients [12].

The industrial sector is the second largest market category and is dominated by the resource exploration industries—particularly oil, natural gas and mineral exploration companies [31]. Frequent coverage and timely delivery are not as vital as in the renewable resources area. Usually seasonal coverage and delivery within the month is adequate. During the past few years firms that have been actively using LANDSAT data have developed in-house processing facilities and have established databases with scenes acquired during each of the four seasons. It is possible that this part of the market may approach saturation in the near-term. However, new firms are beginning to employ LANDSAT data, and so the market may be driven more by expanded number of users than by increased demand among

*Not including USDA information processing costs.

existing users [20]. Counterbalancing this trend is the worldwide petroleum glut, which has reduced speculative searches for new sources of petroleum.

The industrial market is characterized by relatively low data volumes but an ability to pay, which bears more of a relationship to value than the other market segments. Data, once acquired, has value for years afterwards. The new and narrower spectral bands of the Thematic Mapper data will be valuable in mineral and petroleum exploration, and a strong initial demand for TM data on the part of these users is anticipated. The industrial sector has expressed a desire to acquire stereo data which is not available from LANDSAT D and D' but will be available from the French SPOT System.

There has been limited operational use of multi-spectral data in the forestry industries. St. Regis Paper Company is now using MSS data in a forest resource information system [1]. Agribusinesses, although aware of the LANDSAT program, have been reluctant to actively use the data [31]. A recent market study identified potential private users with requirements which LANDSAT now has the potential to fill, including utilities, construction companies, agribusinesses, or which higher resolution MLA systems will fill, including mining engineering, bridge, tunnel and elevated highway construction contractors [31].

Foreign users have made up about one-third of total EDC data sales. The composition of the foreign sector is believed to be similar to the U.S. groups (federal, industrial, academic, and state and local governments) and will have similar requirements [20]. The developing countries and some developed countries (such as Canada, Australia to a certain degree, Brazil and South Africa, which have substantial areas, small but well trained scientific populations and economies which can support investments in remote sensing) place high value on the LANDSAT system [12]. For many developing countries there are no alternatives to LANDSAT's reliable, inexpensive provision of data on natural resources. Small countries, cloudy countries and countries with finely segmented landscapes do not have much interest in the present system, but look to future spacecraft imaging radars to overcome the cloud cover problem, and to SPOT and TM for high resolution and multi-spectral data [12].

4.3 Competition

Starting in 1984 LANDSAT will face competition if, as is currently scheduled, France launches its developmental satellite earth observation program, SPOT. The SPOT satellite will contain two identical high resolution visible (HRV) range instruments. These instruments will have a resolution of 20 meters in three spectral bands (in the visible and near infrared portions of the spectrum) and 10 meters in black and white. During ground processing, 20 and 10 meter resolution images can be combined into a product appearing to have an enhanced resolution beyond the multispectral image. A unique feature of the SPOT imaging system is the off-nadir viewing capability made possible through the use of multi-linear arrays (MLA) of solid state detectors. This allows revisit coverage at intervals from one to several days, and the ability to record stereoscopic pairs of images of a particular area. SPOT has a 26-day repeat cycle [32, 33].

A market for SPOT data is expected to be found among those involved in oil and mineral exploration, topographic and land use mapping, crop and environmental monitoring, coastal zone studies and general research activities. SPOT Image, the privately-owned company that will market SPOT, plans to establish agreements with ground stations, giving the stations exclusive rights to market SPOT within their own countries [33]. The payment fees to these stations are structured so as to be essentially proportional to the amount of data received by them. SPOT Image has tentatively priced their product (high density tape) at about $1,000 per scene. A SPOT scene is approximately one-fourth the area of a TM scene (currently priced at $2,800) and has three spectral bands, as compared to the TM's seven. The implications on the market can only be guessed, but it is likely that those applications that do not have need for full TM scenes will find SPOT somewhat less expensive.

4.4 Market Forecast

The past decade has seen many major developments in the state of the art of land remote sensing. A space hardware and a ground data processing technology base have been developed. An enormous amount of data have been collected from the LANDSAT satellites and have been processed into film and tape information products. These information products, having application in both renewable and nonrenewable resource management areas, have been available to and used by both federal and nonfederal customers. Considerable progress has been made toward the development of a good technology foundation upon which estimates and

projections can be made with respect to the cost and capability of data collection and processing. During this same time, however, little progress has been made with respect to understanding the market dynamics for resulting information products, although a number of market studies have been undertaken [31, 34, 35, 36]. Little information is available that relates potential sales of information products to the multiple attributes such as resolution, number of spectral bands, price and competition. Because of the brief period of performance of this reported study, it was not possible to develop new data—that is, it was not possible to perform an in-depth market study, nor was it possible to make independent cost and performance estimates. Since assessments and projections were necessary, they were made based upon review of previous work, the establishment of historical costs, performance and sales databases, and interviews with both users and suppliers of data products.

A summary of historical data is presented in Figure 4.1 and indicates thousands of MSS scenes (imagery plus tape) delivered as a function of time. Also indicated are the Department of Commerce estimates of MSS scenes that will be delivered in FY 1983 and 1984 [20]. It should be noted that there have been significant changes in pricing policy over the period of time shown, culminating with a large price increase (approximately two to three times) in October 1982 [30]. Also, TM scenes have recently become available and will cause a gradual switch by some users from MSS (80 meter) to TM (30 meter) information products.

The following paragraphs summarize the market forecasts that have been used in the financial analyses which are presented in Section 6 of this report. Because we have tried within the scope of the current effort to play the role of an entrepreneur formulating a business plan. the market forecasts are felt to be conservative—"blue sky" applications have not been included. Thus, there is likely to be considerable upside potential with but limited downside risk. Also, no consideration has been given to major changes in markets that may result from technology changes (for example, the impact of low cost processing on demand has not been considered) or from market development.

The market forecasts are based upon a market segmentation as indicated in Figure 4.2. The market forecasts are segmented by user (federal, industrial, state/local government/academia and foreign), product type (tape and imagery) and

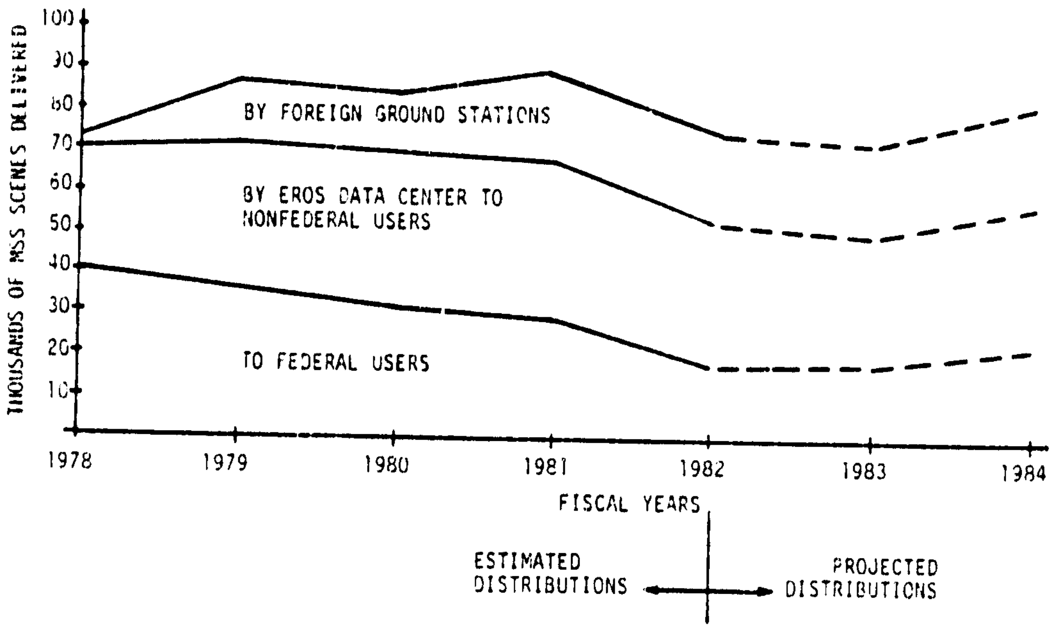


FIGURE 4.1 GLOBAL DISTRIBUTION OF MSS DATA ESTIMATED AND PROJECTED FISCAL YEARS 1978 THROUGH 1984

(SOURCE: TRANSFER OF THE CIVIL OPERATIONAL EARTH OBSERVATION SATELLITE TO THE PRIVATE SECTOR (DRAFT), U.S. DEPARTMENT OF COMMERCE, JANUARY 1983)

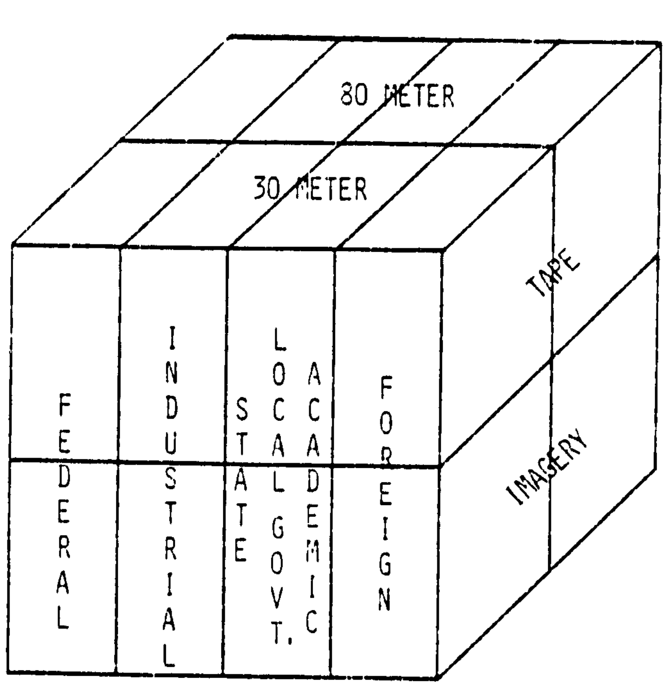


FIGURE 4.2 MARKET SEGMENTATION MODEL

resolution (30 and 80 meters). Thus forecasts have been made for 30 and 80 meter resolution tape and 30 and 80 meter film products to four market segments. It should again be noted that the information products have many attributes including medium (film or tape), resolution, number and location of spectral bands, timeliness of delivery, frequency of observation, proprietariness and dimensions of scene (partial scenes). It should be noted that many of these attributes have not been explicitly considered in this analysis primarily because of lack of data upon which to base forecasts. It should however be pointed out that pricing by product attribute (other than resolution and medium that have been explicitly considered herein) may prove to have great impact upon projected revenues. This is discussed in following paragraphs.

Figures 4.3 and 4.4 illustrate the revenue forecast and are based upon a review of previous studies as well as discussions with users, agencies and suppliers. Considerable judgment has been used in arriving at these figures, the rationale for which follows. Figure 4.3 presents the revenue forecast in constant 1983 dollars and Figure 4.4 presents the forecast in current dollars based upon a continuing 6 percent inflation rate. Since commercial ventures are being evaluated, current dollars are used in the financial analyses. The revenue forecast is based upon the specific timing of events as illustrated in Figure 3.1 (most important is the assumed TM failure in FY 1987 and re-establishment of a 30 meter capability in FY 1991), pricing policy and price elasticity estimates, market share estimates (assuming competition from SPOT and perhaps other sources), user transitions from 80 to 30 meter information products and nominal demand estimates.

The rationale behind the forecast is as follows:

Federal Government Market

The federal sector is characterized by relatively stable budgets which are likely to grow slightly (in real terms) with time. This growth will be primarily the result of price increases of the information products as price adjustments are made towards the maximization of revenue of the business entity. Information products will be acquired principally for renewable resource applications and there is some but little interest or need for stereo data (this data becomes available in FY 1987). The basic attitude of the federal market is to "buy American." This implies a very high market share for a U.S. commercial corporation independent of competition from foreign entities. Because of the large quantity of data required on a continuing basis for monitoring the renewable resources, it is important to acquire

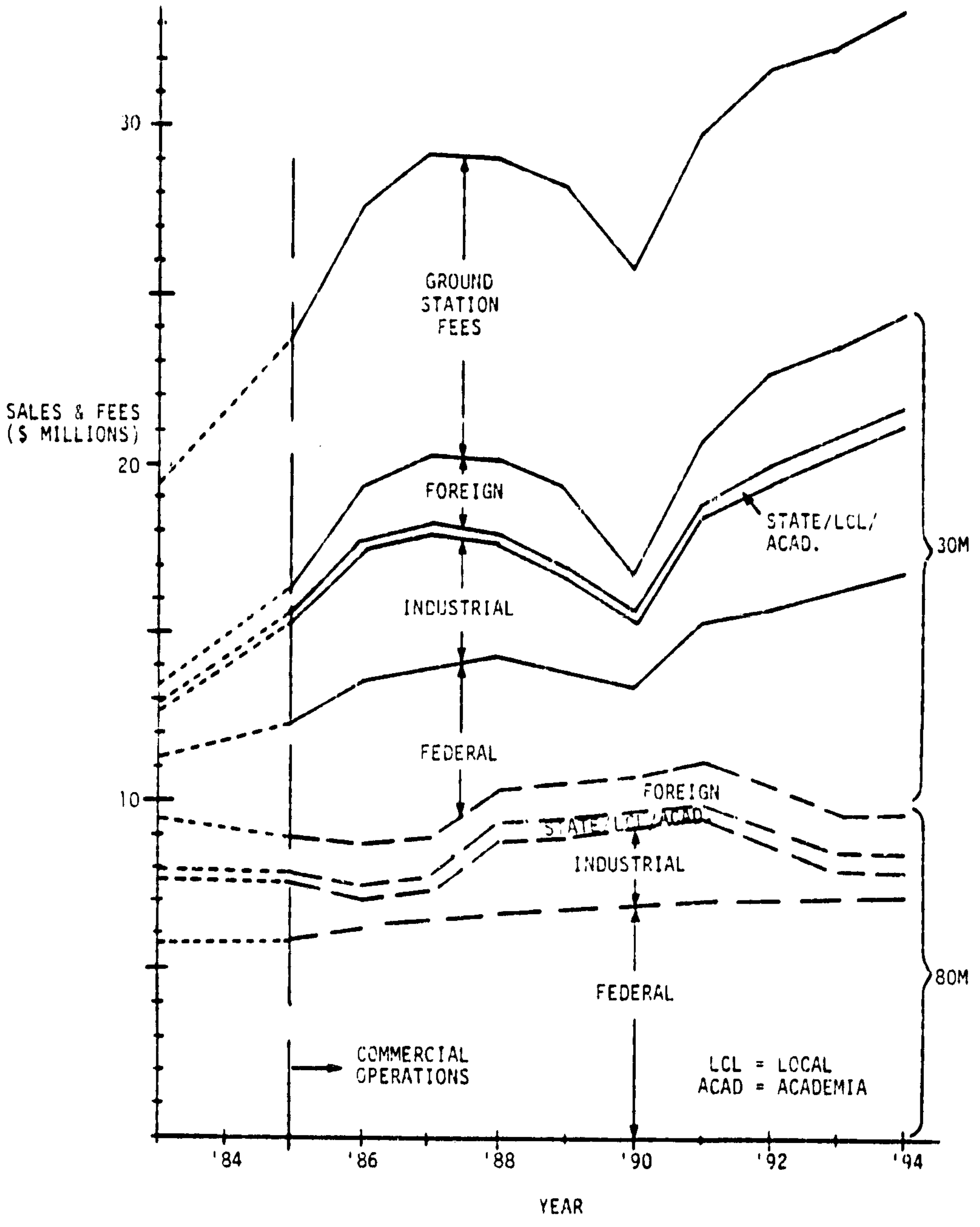


FIGURE 4.3 REVENUE FORECAST BY MARKET SEGMENT AND PRODUCT CLASS (CONSTANT 1983 DOLLARS)

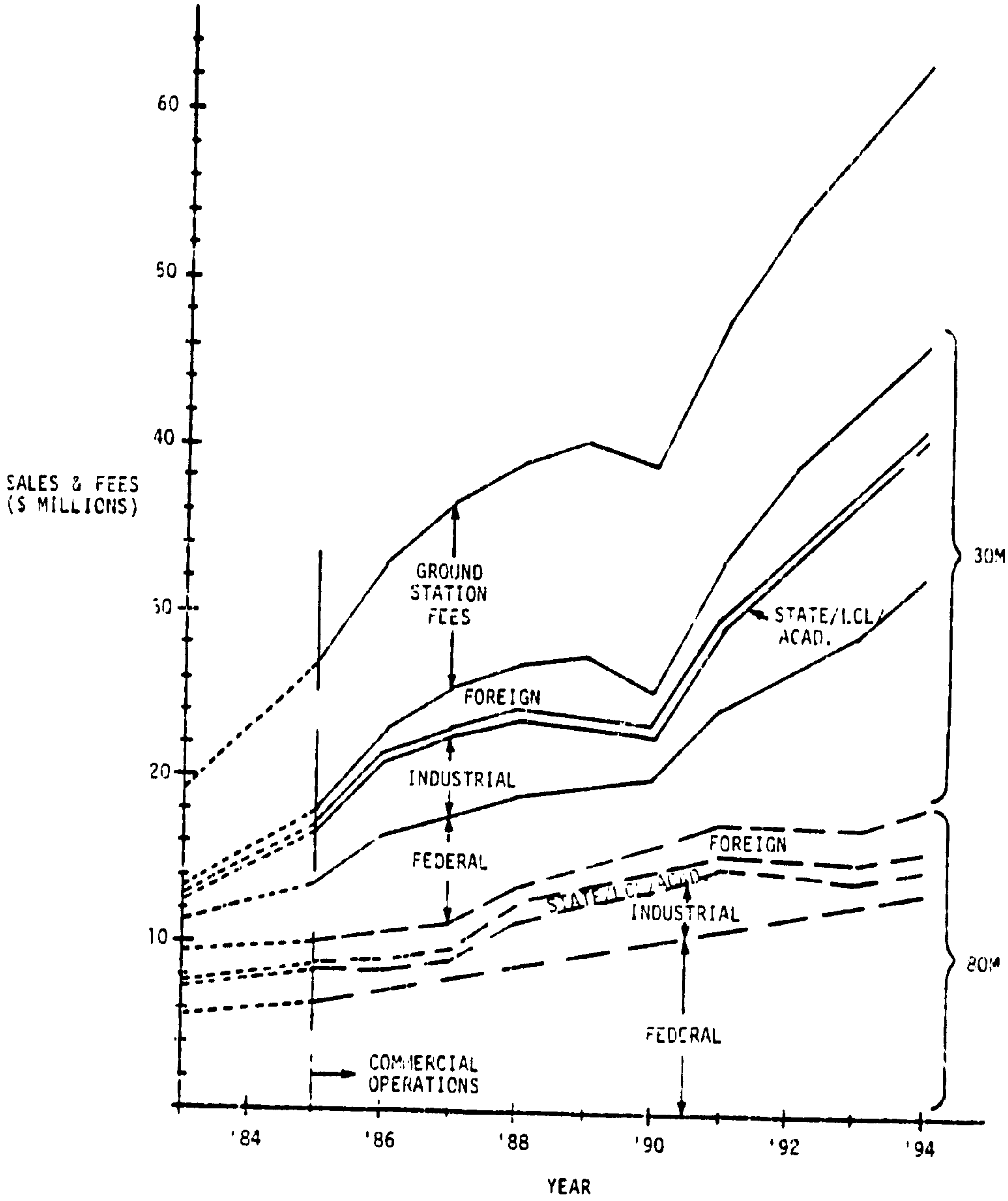


FIGURE 4.4 REVENUE FORECAST BY MARKET SEGMENT AND PRODUCT CLASS (CURRENT DOLLARS - 6% ANNUAL INFLATION RATE)

Econ

low price information products. This is the primary reason for assuming continued reliance upon 80 meter information.

It is assumed that the demand for 80 meter information products will remain relatively constant with time. The demand is basically related to renewable resources. Of particular importance are information products concerning foreign agricultural products. Although 30 meter resolution may be desirable, it is anticipated that the combination of large volume required and high price will, to a large extent preclude its use for renewable resource applications. It is assumed that the demand for these products will continue well into the future and will be independent of the availability of higher resolution information products. It is also assumed that USDA's domestic agricultural reporting services will not rely upon remotely-sensed data. If this changes, then the demand (together with budgets) will increase, possibly by several thousand scenes per year. This would necessitate a budget growth and is probably the only major growth area in the federal sector.

With respect to 30 meter data there is little or no historical data upon which to base forecasts because 30 meter data has not been available until recently. It is assumed that 30 meter information products will be used primarily for experimentation and for nonrenewable resource applications. For these applications, because of the relatively small volume of data required, higher prices can be afforded and 30 meter information is more attractive than 80 meter information. When the LANDSAT D' thematic mapper fails, it is assumed that data purchases will continue (but at a decreasing rate) from archived data. When an operational thematic mapper or its 30 meter equivalent is reintroduced, 30 meter information product sales will pick up and prices will be increased as adjustments are made towards the maximization of revenue. Again, the basic attitude of the federal market is to "buy American." Because of the nonrenewable resource applications, there will be some increase in demand due to the availability of stereo data.

Industrial Market

It is assumed that during the decade of interest (the ten year span of the financial analysis) the resource exploration industry will continue to be the primary source of demand for information products. The market to date has been dominated by the resource exploration companies which currently are likely to continue to do their own data analysis. This implies that the cost of the data is but a small fraction of the total cost. The value of data products significantly exceeds the price paid for the products. Therefore, prices can be increased significantly without reducing the revenue.

It is anticipated that this market will be significantly impacted by the availability of 30 meter data. Therefore the demand for 80 meter products will fall off when 30 meter data becomes available from the thematic mapper. When stereo (80 meter) data is available, demand will increase until 30 meter stereo data is available. Since the market can stand significantly higher prices, attribute pricing may be used (nondiscriminatory) to further increase revenue by charging higher prices. If price is related to quantity purchased with significant price breaks for large quantities, prices may be kept low to federal users and high to industrial users. High prices would then also be charged to foreign and state/local users). Another alternative would be to charge by spectral bands—this is likely to separate by renewable and nonrenewable resources. The effect of this type of pricing, though not used in the financial analysis, is discussed in following paragraphs.

Industrial demand will continue to increase at a constant annual level. Market share will however decrease over time because of product availability from other sources, i.e., competition from SPOT and other systems. Market share for 80 meter products will stabilize at about 70 percent because of a basic "desire to buy American."

Market share for 30 meter products will be more directly affected by SPOT and the unavailability of new 30 meter data because of the assumed demise of LANDSAT D'. Thus, market share will erode to a low of 30 percent in 1990 before again increasing and stabilizing at about 60 percent.

State/Local Government/Academia

This industry segment is characterized by relatively small budgets for the acquisition of information products. It is anticipated that budgets will increase slowly with time as the value of the information products becomes an accepted fact. Information products will be used primarily for nonrenewable resource applications and for research. Because of the large area covered by a scene and slow changes being observed, a relatively small demand is forecast. It is anticipated that 30 meter products will be desired but that due to the relatively high price and fixed budgets, a relatively large quantity of 80 meter products will be acquired. It is anticipated that the bulk of the information products will be purchased from a U.S. source.

Foreign Market

The foreign market consists of franchising foreign ground stations and receiving annual user fees and the sale of information products through these ground stations. It is assumed that the number of franchised ground stations will remain relatively constant over the next decade. It is assumed that maintaining and demonstrating continuity of data will be important in maintaining an active franchise operation.

It is assumed that the foreign ground stations will sell information products that they cannot receive by direct readout. These information products will be obtained from the U.S. organization. It is assumed that 25 percent of the revenue obtained from these sales by the foreign ground stations will be kept by the ground stations and 75 percent of the revenue will be paid to the U.S. organization for the information products.

It is assumed that the foreign demand for 80 meter information products will continue to grow for several years and will then stabilize. If foreign countries decide to acquire worldwide renewable resource data (such as USDA's Foreign Agriculture Service does) this demand could increase significantly. It is assumed that competitive systems will make significant inroads with respect to market share.

Similar forecasts apply for 30 meter information products. Very significant growth is forecast in this area. However, market share will be significantly eroded by competition and the lack of new 30 meter data resulting from the gap caused by failure of LANDSAT D' and the launching of LANDSAT F.

In summary, it is anticipated that revenue from 80 meter information products will remain relatively constant over the next decade. This is the result of a combination of many factors including a slow growth in basic demand for renewable resource applications, the availability of 80 meter stereo data, competition from other systems and the availability of 30 meter information products. It should be noted that the use of satellite data by the USDA domestic reporting services could change this forecast substantially. Also, the use of worldwide crop information on a continuous basis by other nations could also substantially increase the forecast. It is anticipated that revenue from 30 meter information products will increase substantially over the next decade. The growth will be significantly affected by an anticipated gap in the availability of new 30 meter information products (this is the primary reason for the dip (1988-1990) in 30 meter revenue)

and competition from other satellite systems. It has been assumed that there will be only one U.S. organization providing information products. More will be said about this in Section 8.

The revenue forecast is based upon the detailed data presented in Figures 4.5 and 4.6 (all in constant 1983 dollars) for 80 meter and 30 meter information products, respectively, and the price elasticity estimates presented in Figures 4.7 and 4.8. Price elasticity was established by estimating the quantity which would be sold at three different price levels. Two straight lines are passed through the three points as illustrated in Figure 4.7 thus establishing the price-quantity relationship. The specific estimates utilized are presented in Figure 4.7 and illustrated graphically in Figure 4.8.

Referring to Figure 4.8, the dotted curves indicate unit elasticities or constant annual budgets (i.e., price x quantity = annual budget). When the solid curves are above the dotted curves it is implied that budgets will be increased to accommodate price increases. It is thus evident that the federal users have been assumed to be budget constrained within a year (it is assumed that budgets can vary from year to year as indicated by the nominal prices and quantities in Figures 4.5 and 4.6. However, as prices are varied from their nominal values, quantities are adjusted according to the assumed elasticities). As prices increase, quantities demanded decrease by approximately the same amount. This is in contrast to the industrial sector where it is assumed that significant price increases will have but little effect on demand. The state/local government/academia segment is also assumed to be budget constrained but to a slightly lesser degree (because of diversity) than the federal sector. The foreign sector, assumed to be a composite of the three other sectors, is assumed to have some budget flexibility but less than that of the industrial sector.

A few comments must be made with respect to optimum pricing, that is, pricing to maximize revenue. The optimum price is established by finding the point of tangency of the constant budget (by varying the budget level) curve with the price elasticity curv[illegible] resented in Figure 4.8. Assuming that nondiscriminatory attribute pricing can be achieved so that the optimum price can be charged in each market segment, then the price and revenue as indicated in Table 4.1 can be achieved. Table 4.1 indicates optimal price to the federal sector is 2.5 times the nominal price used in the analysis with a resulting revenue of 1.25 times that assumed. The net effect of such optimum pricing (across all market segments)

ORIGINAL PAGE IS
OF POOR QUALITY

FEDERAL MARKET (80 METER RESOLUTION)

	1983	1985	1986	1987	YEAR 1988	1989	1990	1991	1992	1993	1994
NOM.PRICE											
TAPE	650	650	650	650	650	650	650	650	650	650	650
FILM	45	45	45	45	45	45	45	45	45	45	45
NOM.QUANT											
TAPE	7600	7600	7600	7600	7600	7600	7600	7600	7600	7600	7600
FILM	20085	20085	20085	20085	20085	20085	20085	20085	20085	20085	20085
ACT.PRICE											
TAPE	650	650	700	750	800	850	900	1000	1000	1000	1000
FILM	45	45	50	55	60	65	70	75	75	75	75
ACT.QUANT											
TAPE	7600	7600	7366	7132	6898	6665	6431	5963	5963	5963	5963
FILM	20085	20085	19192	18300	17407	16514	15622	14729	14729	14729	14729
MKT SHARE											
TAPE	100	100	100	100	100	100	100	100	100	100	100
FILM	100	100	100	100	100	100	100	100	100	100	100
REVENUE											
TAPE	4940000	4940000	5156300	5349231	5518769	5664923	5787692	5963077	5963077	5963077	5963077
FILM	903825	903825	959617	1006482	1044420	1073432	1093517	1104675	1104675	1104675	1104675
TOTAL	5843825	5843825	6115924	6355712	6563189	6738355	6881209	7067752	7067752	7067752	7067752

INDUSTRIAL MARKET (80 METER RESOLUTION)

	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
NOM.PRICE											
TAPE	650	650	650	650	650	650	650	650	650	650	650
FILM	45	45	45	45	45	45	45	45	45	45	45
NOM QUANT											
TAPE	2000	2000	1000	1000	3000	3000	3000	3000	2000	1000	1000
FILM	10000	6000	4000	4000	6000	6000	6000	4000	3000	3000	3000
ACT.PRICE											
TAPE	650	650	700	750	800	850	900	1000	1000	1000	1000
FILM	45	45	50	55	60	65	70	75	75	75	75
ACT.QUANT											
TAPE	2000	2000	946	992	2965	2954	2942	2919	1946	973	973
FILM	10000	6000	3991	3982	5960	5947	5933	3947	2960	2960	2960
MKT SHARE											
TAPE	100	100	95	90	80	75	70	70	70	70	70
FILM	100	100	95	90	80	75	70	70	70	70	70
REVENUE											
TAPE	1300000	1300000	662442	669808	1897846	1883077	1853654	2043462	1362308	681154	681154
FILM	450000	270000	189878	197120	286080	289900	290733	207200	155400	155400	155400
TOTAL	1750000	1570000	852320	866928	2183926	2172977	2144387	2250662	1517708	836554	836554

STATE/LCL GVT/ACAD MARKET (80 METER RESOLUTION)

	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
NOM.PRICE											
TAPE	650	650	650	650	650	650	650	650	650	650	650
FILM	45	45	45	45	45	45	45	45	45	45	45
NOM.QUANT											
TAPE	320	350	400	400	450	500	500	500	500	500	500
FILM	1500	1700	1900	2100	2300	2500	2500	2500	2500	2500	2500
ACT.PRICE											
TAPE	650	650	700	750	800	850	900	1000	1000	1000	1000
FILM	45	45	50	55	60	65	70	75	75	75	75
ACT.QUANT											
TAPE	320	350	391	382	419	454	442	419	419	419	419
FILM	1500	1700	1837	1960	2070	2167	2083	2000	2000	2000	2000
MKT SHARE											
TAPE	100	100	100	100	90	90	90	90	90	90	90
FILM	100	100	100	100	90	90	90	90	90	90	90
REVENUE											
TAPE	208000	227500	273538	286154	301569	347192	358269	377308	377308	377308	377308
FILM	67500	76500	91833	107800	111780	126750	131250	135000	135000	135000	135000
TOTAL	275500	304000	365372	393954	413349	473942	489519	512308	512308	512308	512308

FOREIGN MARKET (80 METER RESOLUTION)

	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
NOM.PRICE											
TAPE	650	650	650	650	650	650	650	650	650	650	650
FILM	45	45	45	45	45	45	45	45	45	45	45
NOM.QUANT											
TAPE	1250	1500	1650	1700	1800	1900	2000	2000	2000	2000	2000
FILM	14400	15000	16500	17000	18000	19000	20000	20000	20000	20000	20000
ACT.PRICE											
TAPE	650	650	700	750	800	850	900	1000	1000	1000	1000
FILM	45	45	50	55	60	65	70	75	75	75	75
ACT.QUANT											
TAPE	1250	1500	1625	1648	1717	1783	1846	1785	1785	1785	1785
FILM	14400	15000	16317	16622	17400	18156	18889	18667	18667	18667	18667
MKT SHARE											
TAPE	100	100	95	80	60	50	50	50	50	50	50
FILM	100	100	95	80	60	50	50	50	50	50	50
FEE SHARE	100	75	75	75	75	75	75	75	75	75	75
REVENUE											
TAPE	812500	731250	810277	741462	618092	568356	623077	669231	669231	669231	669231
FILM	648000	506250	581281	548533	469800	442542	495873	525000	525000	525000	525000
TOTAL	1460500	1237500	1391558	1289995	1087892	1010897	1118910	1194231	1194231	1194231	1194231

TOT REVEN	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
TAPE	7260500	7198750	6902565.	7046654.	8336277.	8463548.	8622692.	9053077.	8371923.	7690769.	7690769.
FILM	2069325	1756575	1822309.	1859935.	1912080	1932623.	2011333.	1971875	1920075	1920075	1920075
TOTAL	9329825	8955325	8724874.	8906589.	10248357	10396171	10634026	11024952	10291998	9610844.	9610844.

FIGURE 4.5 MARKET FORECAST FOR 80 METER DATA PRODUCTS (CONSTANT 1983 DOLLARS)

ORIGINAL PAGE IS
OF POOR QUALITY

FEDERAL MARKET (30 METER RESOLUTION)

	1983	1985	1986	1987	YEAR 1988	1989	1990	1991	1992	1993	1994
NOM.PRICE											
TAPE	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800
FILM	45	45	45	45	45	45	45	45	45	45	45
NOM.QUANT											
TAPE	570	1000	1500	1500	1200	1000	800	1200	1500	1800	2000
FILM	6800	10000	15000	18000	12000	10000	8000	12000	15000	18000	20000
ACT.PRICE											
TAPE	2800	2800	2800	2800	2800	2800	2800	3000	3200	3300	3400
FILM	45	45	50	55	60	65	70	75	75	75	75
ACT.QUANT											
TAPE	570	1000	1500	1500	1200	1000	800	1166	1414	1671	1829
FILM	6800	10000	14333	13667	10400	8222	6222	8800	11000	13200	14667
MKT SHAR%											
TAPE	100	100	100	100	100	100	100	100	100	100	100
FILM	100	100	100	100	100	100	100	100	100	100	100
REVENUE											
TAPE	1596000	2800000	4200000	4200000	3360000	2800000	2240000	3497143	4525714	5515714	6217143
FILM	306000	450000	716667	791667	624000	534444	435556	660000	825000	990000	1100000
TOTAL	1902000	3250000	4916667	4991667	3984000	3334444	2675556	4157143	5350714	6505714	7317143

INDUSTRIAL MARKET (30 METER RESOLUTION)

	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
NOM.PRICE											
TAPE	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800
FILM	45	45	45	45	45	45	45	45	45	45	45
NOM.QUANT											
TAPE	500	1000	1500	2000	2000	2000	2000	2000	2000	2000	2000
FILM	1000	2000	3000	4000	4000	4000	4000	4000	4000	4000	4000
ACT.PRICE											
TAPE	2800	2800	2800	2800	2800	2800	2800	3000	3200	3300	3400
FILM	45	45	50	55	60	65	70	75	75	75	75
ACT.QUANT											
TAPE	500	1000	1500	2000	2000	2000	2000	1993	1986	1982	1979
FILM	1000	2000	2993	3982	3973	3964	3956	3947	3947	3947	3947
MKT SHAR%											
TAPE	100	100	90	70	60	50	30	50	60	60	60
FILM	100	100	90	70	60	50	30	50	60	60	60
REVENUE											
TAPE	1400000	2800000	3780000	3920000	3360000	2800000	1680000	2989296	3812571	3924643	4036286
FILM	45000	90000	134700	153316	143040	120844	83067	148000	177600	177600	177600
TOTAL	1445000	2890000	3914700	4073316	3503040	2920844	1763067	3137286	3990171	4102243	4213886

STATE/LCL GVT/ACAD MARKET (30 METER RESOLUTION)

	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
NOM.PRICE											
TAPE	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800
FILM	45	45	45	45	45	45	45	45	45	45	45
NOM.QUANT											
TAPE	10	50	75	100	100	100	100	100	100	100	100
FILM	1000	1500	1500	1200	1000	1000	1000	1000	1000	1000	1000
ACT.PRICE											
TAPE	2800	2800	2800	2800	2800	2800	2800	3000	3200	3300	3400
FILM	45	45	50	55	60	65	70	75	75	75	75
ACT.QUANT											
TAPE	10	50	75	100	100	100	100	98	96	95	94
FILM	1000	1500	1450	1120	900	867	833	800	800	800	800
MKT SHAR%											
TAPE	100	100	100	90	80	70	70	80	90	100	100
FILM	100	100	100	90	80	70	70	80	90	100	100
REVENUE											
TAPE	28000	140000	210000	252000	224000	196000	196000	234857	275657	312321	318143
FILM	45000	67500	72500	55440	43200	39433	40833	48000	54000	60000	60000
TOTAL	73000	207500	282500	307440	267200	235433	236833	282857	329657	372321	378143

FOREIGN MARKET (30 METER RESOLUTION)

	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
NOM.PRICE											
TAPE	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800	2800
FILM	45	45	45	45	45	45	45	45	45	45	45
NOM.QUANT											
TAPE	150	300	600	1000	1400	1800	2000	2000	2000	2000	2000
FILM	1500	3000	6000	10000	14000	18000	20000	20000	20000	20000	20000
ACT.PRICE											
TAPE	2800	2800	2800	2800	2800	2800	2800	3000	3200	3300	3400
FILM	45	45	50	55	60	65	70	75	75	75	75
ACT.QUANT											
TAPE	150	300	600	1000	1400	1800	2000	1971	1943	1929	1914
FILM	1500	3000	5933	9778	13533	17200	18689	18667	18667	13667	16667
MKT SHAR%											
TAPE	100	100	95	80	60	50	30	40	50	50	50
FILM	100	100	95	80	60	50	30	40	50	50	50
FEE SHAR%	100	75	75	75	75	75	75	75	75	75	75
REVENUE											
TAPE	420000	630000	1197000	1680000	1764000	1890000	1260000	1774286	2331429	2386607	2440714
FILM	67500	101250	211375	322667	365400	419250	297500	420000	525000	525000	525000
TOTAL	487500	731250	1408375	2002667	2129400	2309250	1557500	2194286	2856429	2911607	2965714

	1983	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
TOT REVEN											
TAPE	3444000	6370000	9387000	10052000	8708000	7686000	5376000	8495571.	10948371	12139286	13012286
FILM	467500	708750	1135242.	1283089.	1175640	1121972.	856955.6	1276000	1581600	1752600	1862600
TOTAL	3911500	7078750	10522242	11335089	9883640	8807972.	6232956.	9771571.	12529971	13891886	14874886

FIGURE 4.6 MARKET FORECAST FOR 30 METER DATA PRODUCTS (CONSTANT 1983 DOLLARS)

Econ

ORIGINAL PAGE IS
OF POOR QUALITY

PRICE QUANTITY DATA	FEDERAL		INDUSTRIAL		STATE/LCL GVT/ACAD		FOREIGN	
	FILM	TAPE	FILM	TAPE	FILM	TAPE	FILM	TAPE
PRICE X1	1	1	1	1	1	1	1	1
X2	2	2	2	2	2	2	2	2
X3	3	3	3	3	3	3	3	3
QUANT #1	1	1	1	1	1	1	1	1
#2	.6	.6	.98	.95	.7	.7	.9	.8
#3	.4	.4	.8	.8	.4	.4	.6	.6

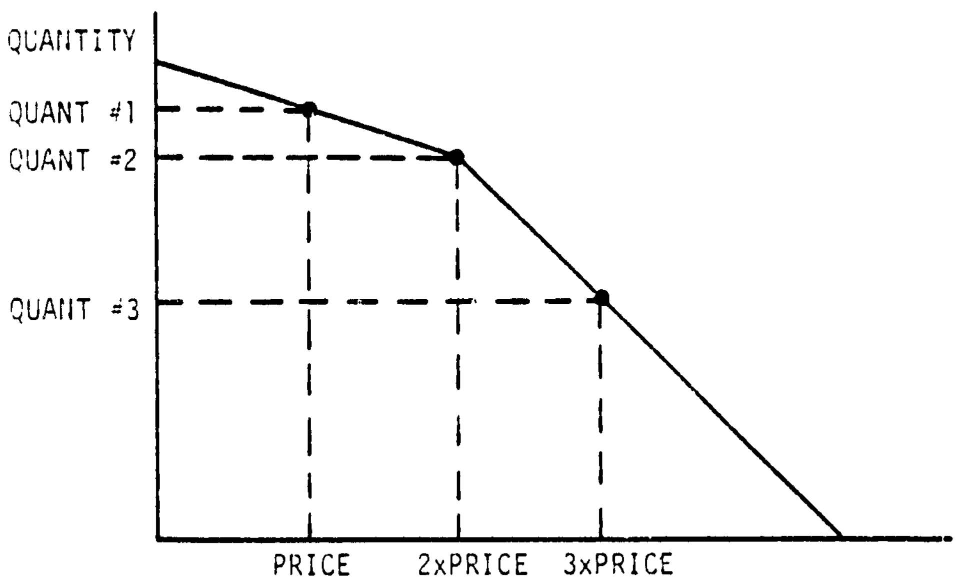


FIGURE 4.7 ANTICIPATED PRICE ELASTICITY

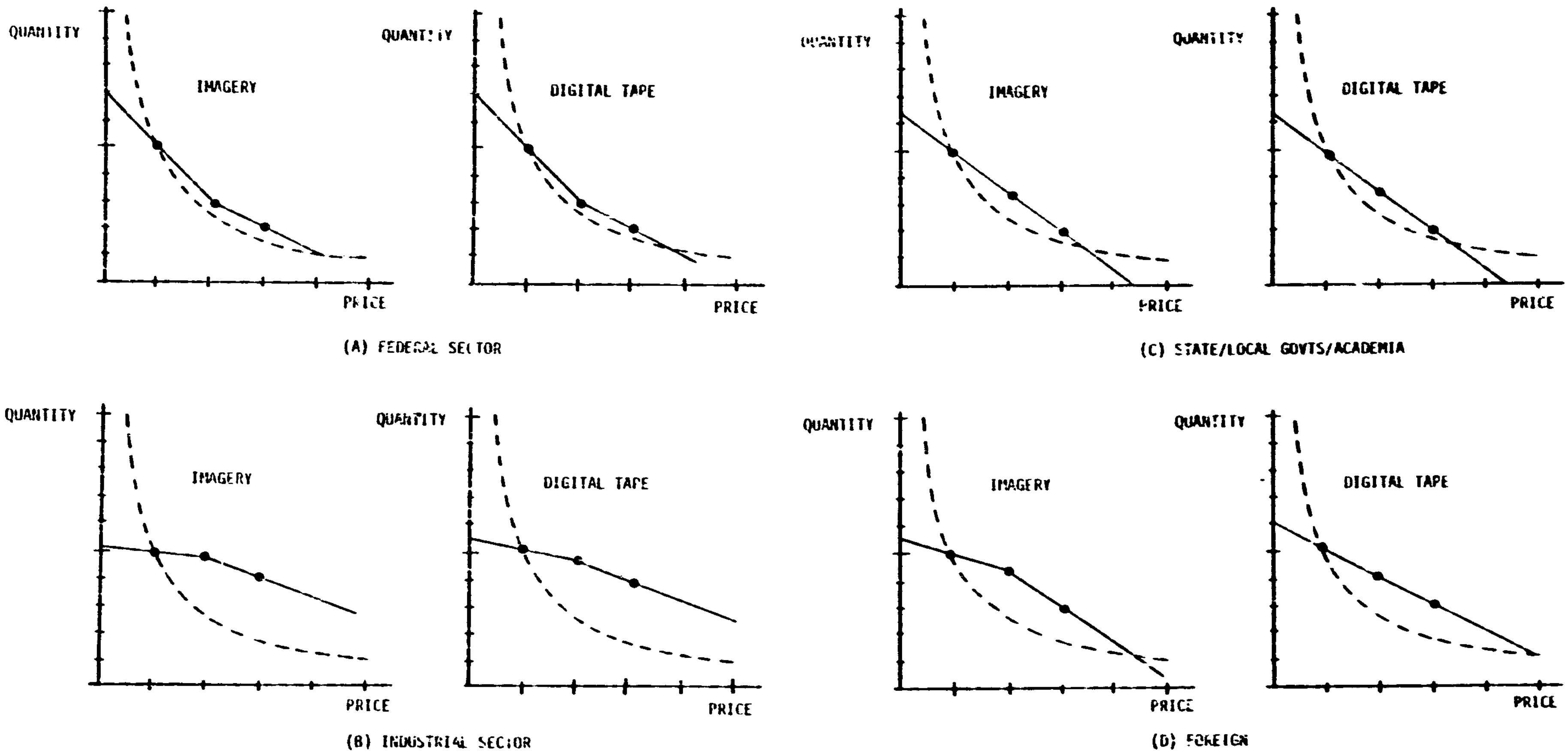


FIGURE 4.8 ANTICIPATED PRICE ELASTICITY BY MARKET SEGMENT

TABLE 4.1 OPTIMUM PRICE & RESULTING REVENUE (RELATIVE)				
MARKET SECTOR	IMAGERY		TAPE	
	PRICE	REVENUE	PRICE	REVENUE
FEDERAL	2.5x	1.25x	2.5x	1.25x
INDUSTRIAL	3.7x*	2.5x*	4.2x	2.6x
STATE/LOCAL/ACAD.	2.2x	1.4x	2.2x	1.4x
FOREIGN	2.5x	1.9x	3.0x	1.8x

*A PRICE INCREASE RELATIVE TO THE NOMINAL PRICE OF 3.7 TIMES RESULTS IN A REVENUE INCREASE OF 2.5 TIMES.

would be to approximately double the estimated total revenue. While this looks very tempting there are problems: competition will generally drive these prices down as will lack of knowledge of the true price-elasticity curves. Therefore, the conservative pricing policy indicated in Figures 4.5 and 4.6, and modified by inflationary increases, was assumed with the gradual increase in prices assumed to seek out the optimum while countering competition and minimizing budgetary process problems particularly among federal, state and local government users.

5. FINANCIAL/ORGANIZATIONAL SCENARIOS (GENERAL)

As stated previously, the ECON efforts were concerned with the analysis and comparison of a limited number of financial and organizational approaches for either transfer of the ownership and operation of the civil operational land remote sensing program to the private sector or government retention. The following basic approaches for commercialization or retention were considered:

1. Continued ownership and operation by the federal government (planned phase-out)
2. Continued ownership and operation by the federal government (establishment of the necessary budgetary line items)
3. Wholly privately-owned and operated by an entity competitively selected
4. Phased private ownership (government ownership and operation with private sector marketing)
5. Legislatively-chartered, privately-owned corporation.

Each of these scenarios is described in the following paragraphs. Each of the scenarios is based upon the schedule of events as indicated in Figure 3.1 and the market and revenue forecasts as described in Section 4.

One of the most controversial issues surrounding commercialization is that of subsidies. Subsidies can take a variety of forms: direct cash subsidy payments; federal loans or loan guarantees; guaranteed federal purchases of information products at a unit price significantly higher than charged to other users; provision of free services such as satellite launches; special tax incentives; or other. The Administration has indicated its opposition to subsidization for commercial civil remote sensing on several grounds including [8]:

- Any form of subsidization (whether increasing cash outflow or reducing revenues) is opposed on the basis of budgetary impact on the efforts to balance the budget
- Subsidization in this area would set undesirable precedents in other areas
- If a commercialization initiative cannot stand the test of the marketplace, it should not be established at all.

This analysis of the various commercialization alternatives was jointly concerned with government cash flows as well as with the financial viability of the commercial endeavors (the feasibility of obtaining funding as well as continuing profitable operations). Because of the anticipated limited market for land remote

sensing information products, combined with the possible competition from remote sensing systems owned by or subsidized by foreign governments and the capital intensive nature of the business, it is shown in Section 6 that viable commercialization endeavors are not likely to be established without significant federal participation, either in the form of subsidies or major ownership/operations roles.

Again it is not possible to consider all subsidization forms or all levels of government ownership/operation. The specific subsidization forms considered include direct cash subsidy payments, equipment transfer values and recoupment policies, and government equity participation. The method of determining the need for subsidies and the specific form of the subsidies are described in Section 6. Three different levels of government participation were considered, namely: a) no participation except for possibly R&D and other support services, b) ownership/operation of the ground and space segments, excluding the marketing and sales functions, and c) ownership/operation of the ground and space segments including the marketing and sales functions.

5.1 Continued Ownership and Operation by the Federal Government (Planned Phase-Out)

Shortly after President Reagan entered office it was announced that the Administration would terminate the commitment to land remote sensing satellite data continuity through the 1980s on the basis that

> It is the Administration's judgment that the present NASA investment in LANDSAT is sufficient to permit evaluation of operational uses of LANDSAT data, and if these uses are cost-effective to attract a private sector owner/operator.
>
> NASA's program to develop, launch and test the two additional satellites already manufactured (LANDSAT D and D') will continue as previously planned. Expansion and extension of the U.S. civil land remote sensing program beyond that already funded by NASA is inconsistent with the need for across the board fiscal restraints....

The two additional satellites, frequently referred to as LANDSAT D" AND D"', then were deleted from the budget [8].

The implication of the above is that the federal government would continue to fund the ground and space segments and the related sales activities associated with remote sensing until the demise of LANDSAT D' or shortly thereafter (i.e.,

sales will most likely continue for the short-term). The annual cost associated with this planned phase-out scenario can be stated in general as*

$$\begin{aligned}\text{Annual Fed. Gov't. Cost(I)} = {} & \text{Operating Cost(I)} + \text{Storage Cost of D'(I)} \\ & + \text{Launch Cost of D'(I)} + \text{R\&D Cost(I)} \\ & + \text{Gov't. Purchases from Other Sources(I)} \\ & - \text{Gov't. Revenue from Nongov't. Sources(I)} \\ & + \text{Interest on Debt(I)} - \text{Tax Revenue(I)}.\end{aligned}$$

This is restated in Table 5.1 together with the government cost computations resulting from the other considered commercialization and retention scenarios. The tax revenue results from taxation of private sector profits resulting from the government expenditures in the private sector. The interest on debt is the interest that must be paid by the federal government on borrowings made to cover the outlays made for the system. It can be shown that to a first order approximation, considering the magnitude of all of the other cost elements, the interest on debt and the generated tax revenue, which tend to offset one another, may be neglected.**

As per the schedule of events indicated in Figure 3.1, it is anticipated that LANDSAT D' will fail in the late 1980s (FY87 or FY88). Therefore, government operating costs associated with the operations of the land remote sensing system would be reduced to zero during this time period. However, government costs will not reduce to zero after the demise of LANDSAT D'. The reason for this is that government agencies will most likely continue to purchase information products from other sources. It can be argued that these purchases need not be made, and that federal budgets associated with land remote sensing can be eliminated. The counter to this argument is that there are benefits associated with the use of the remotely sensed data. These may be in the form of direct cost savings or other indirect benefits. These benefits will be foregone if the remotely sensed data is not used. If it is assumed that the benefits will exceed the cost of the information

*I represents time, years.

**Tax Revenue = 0.5 x Gov't. Cost x Return on Sales(%)/100
Interest on Debt = Gov't. Cost x Interest Rate(%)/100
Interest on Debt - Tax Revenue = [Interest Rate(%) - 0.5 x Return on Sales(%)] x Gov't. Cost/100
= [8% - 0.5 x 10%] x Gov't. Cost/100
Therefore, neglecting interest on debt and generated tax revenues may introduce an error of 3 to 4 percent.

TABLE 5.1 DETERMINATION OF GOVERNMENT COSTS*	
SCENARIO	COST COMPUTATION**
1. GOVERNMENT OWNERSHIP AND OPERATION (PLANNED PHASE OUT)	OPERATING COST(I) + STORAGE COST OF D'(I) + LAUNCH COST OF D'(I) + R&D COST(I) + GOVERNMENT PURCHASE FROM OTHER SOURCES(I) - GOVERNMENT REVENUE FROM NONGOVERNMENT SOURCES(I) + INTEREST ON DEBT(I) - TAX REVENUE(I)
2. GOVERNMENT OWNERSHIP AND OPERATION (CONTINUED OWNERSHIP AND OPERATION)	SPACE SEGMENT COST(I) + GROUND SEGMENT COST(I) + INTEREST ON DEBT(I) - TAX REVENUE(I) - INDUSTRIAL SALES(I) - STATE/LOCAL GOVERNMENT/ACAD. SALES(I) - FOREIGN SALES(I) - USER FEES(I) + R&D COST(I)
3. PRIVATE OWNERSHIP AND OPERATION	GOVERNMENT PAYMENT FOR INFORMATION PRODUCTS(I) + OPERATIONS COSTS(I) - LEASE PAYMENTS(I) - ASSET RECOUPMENT PAYMENTS(I) - TDRSS COST(I) - PROFIT SHARING OR ROYALTY ON SALES(I) + SUBSIDY PAYMENTS(I) + R&D COST(I) + INTEREST ON DEBT(I) - GENERATED TAX REVENUE(I)
4. PHASED PRIVATE OWNERSHIP (PRIVATE SECTOR MARKETING)	GOVERNMENT PAYMENT FOR INFORMATION PRODUCTS(I) + OPERATIONS COSTS(I) - PROFIT SHARING OR ROYALTY ON SALES(I) - GUARANTEED PAYMENTS(I) + R&D COST(I) + INTEREST ON DEBT(I) - GENERATED TAX REVENUE(I)
5. LEGISLATIVELY CHARTERED, PRIVATELY OWNED CORPORATION	GOVERNMENT PAYMENT FOR INFORMATION PRODUCTS(I) + OPERATIONS COSTS(I) - LEASE PAYMENTS(I) - ASSET RECOUPMENT PAYMENTS(I) - TDRSS COST(I) - PROFIT SHARING OR ROYALTY ON SALES(I) + SUBSIDY PAYMENTS(I) + R&D COST(I) - GENERATED TAX REVENUE(I) + INTEREST ON DEBT(I) + EQUITY PURCHASE(I) - DIVIDENDS(I)

*ALL SCENARIOS UTILIZE THE SAME REVENUE FORECAST.
**I REPRESENTS TIME PERIODS (I.E., YEARS).

products (this appears to be a valid assumption since, if this were not the case, any form of commercialization would not be seriously considered) then the cost to the government and/or the general public (not necessarily in the form of budgetary items) after the demise of LANDSAT D' will equal or exceed the cost of the forecasted federal government purchases of information products. This is illustrated conceptually in Figure 5.1 and quantitative results are presented in Section 6.1.

5.2 Continued Ownership and Operation by the Federal Government (Establishment of the Necessary Budget Line Items)

It is assumed for this scenario that a government organization is established for providing land remote sensing operations on a continuing basis. It is

ORIGINAL PAGE IS
OF POOR QUALITY

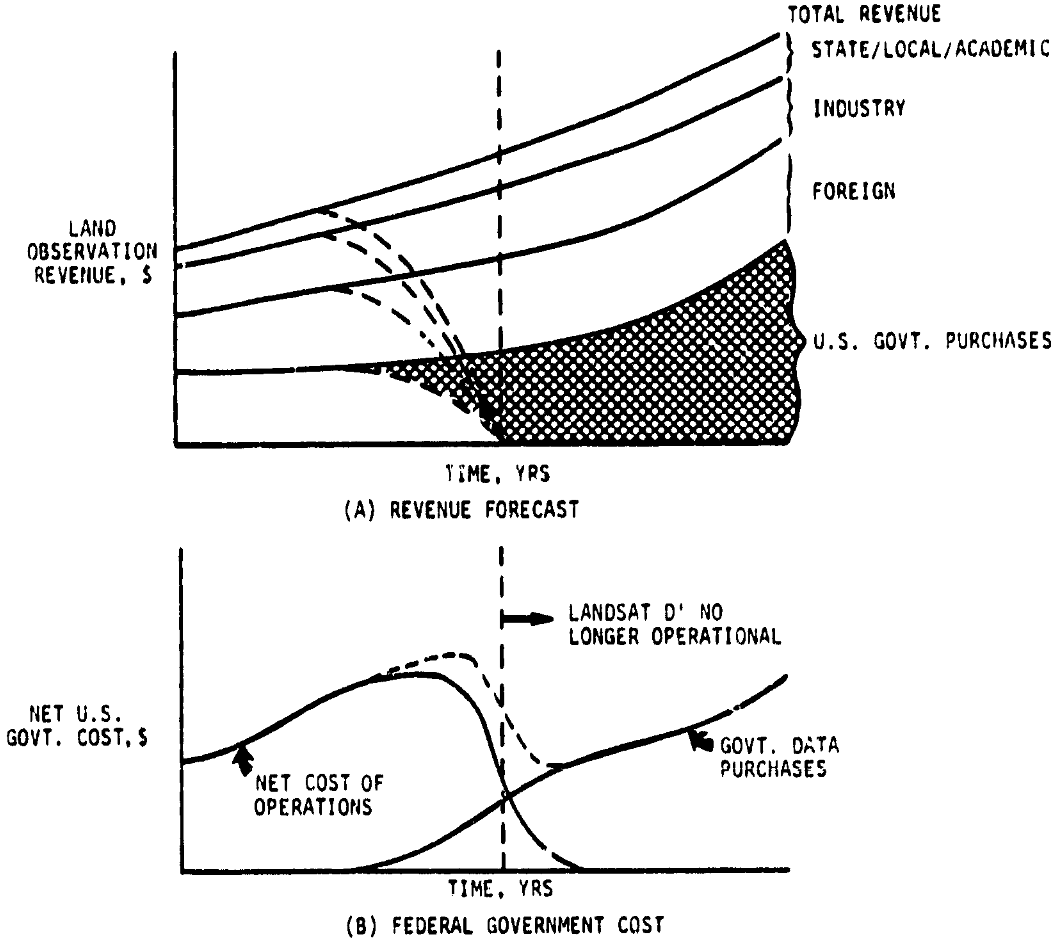


FIGURE 5.1 SCENARIO 1: GOVERNMENT OWNERSHIP & OPERATION (PLANNED PHASE-OUT)

assumed that the operations are based upon the event schedule presented in Figure 3.1. It is assumed that the government organization is similar to that which would be established by the private sector as per the business venture description presented in Section 3. This organization will have a market orientation similar to that of the private sector. The organization will have complete responsibility for the space segment (including maintaining continuity of service), the ground processing segment and marketing and sales (including archiving).

It is likely that differences in organizational efficiency and management objectives will exist between government and private sector operations. These differences, if they exist, are difficult to quantify. No attempt was made as part of this study to quantify these differences. An important area where differences are likely to exist is in marketing and sales. Private sector market orientations differ significantly from that of the government. For example, the private sector

is used to providing incentives (commissions, bonuses, stock options, etc.) to encourage higher productivity from a marketing organization—the government is not. To achieve comparable performance, it is likely that a government organization would have to consider similar incentives to those available in the private sector.

The cost of continuing government ownership and operation of a land remote sensing system may be expressed as follows:

Annual Fed. Gov't. Cost(I) = Space Segment Cost(I) + Ground Segment Cost(I) + R&D Cost(I) - Industrial Sales(I) - State/Local Gov't./Academic Sales(I) - Foreign Sales(I) - User Fees(I) + Interest on Debt(I) - Tax Revenue(I).

For the reasons previously discussed, the net effect of interest on debt and tax revenue is assumed small and not quantified. All of the other costs and revenue items are quantified and are established in Section 6.1.

5.3 Wholly Private Ownership and Operation by an Entity Competitively Selected

The private ownership and operation scenario is based upon providing continuous land remote sensing observation and resulting information products on a continuing basis. Commercialization is assumed to commence at the start of FY85 with all space, ground processing and marketing and sales being accomplished by or for the private sector organization. It is assumed that initially existing ground processing facilities at Goddard Space Flight Center, and archiving and processing facilities at EDC will continue to be utilized. These operations will be integrated into a common facilities at White Sands during FY89.

It is assumed that the private sector venture will utilize existing LANDSAT satellites and will, as indicated in Figure 3.1, phase into the acquisition and operation of other satellites. It is generally assumed in the financial analyses that the ground processing facilities at GSFC and EDC (until FY89) are leased by the private sector and that the LANDSAT D and D' satellites are acquired on a title transfer basis. The effect of lease payments and recoupment payments is investigated by considering the conditions of: a) full repayment (to the government) based upon estimated book value at the time of title transfer or lease rate establishment, and b) no recoupment by the government (i.e., a form of subsidy) for government assets utilized in the private sector operations.

The effect of and the need for annual cash subsidies is also considered. Annual subsidies are established (for both the full recoupment and no recoupment

cases discussed above) by determining the revenue required in order to achieve annual returns on capital that would be necessary to attract capital from the capital market. The difference between forecasted revenue and required revenue is then the required annual subsidy.

The general approach for analyzing the private ownership and operation scenario is illustrated in Figure 5.2. The financial analysis develops pro forma income statements, cash flow projections and balance sheets. The inputs to the analysis (described in detail in Section 6) are the demand or revenue forecast; the schedule of events; fixed and variable costs associated with processing, archiving and sales; capital items including value, timing and depreciation lives; tax structure data and other related information. Also specified are desired return on assets, desired discounted return on investment, debt equity structure, and the lease/transfer options. The result of the financial analysis is the determination of financial performance measures such as annual after-tax profit, annual cash flow, capital requirements, return on assets, payback period and subsidy requirements. The parameters are thus those of a business entity which is viable from the point of view of the financial community—i.e., it is likely that the necessary funding would be available.

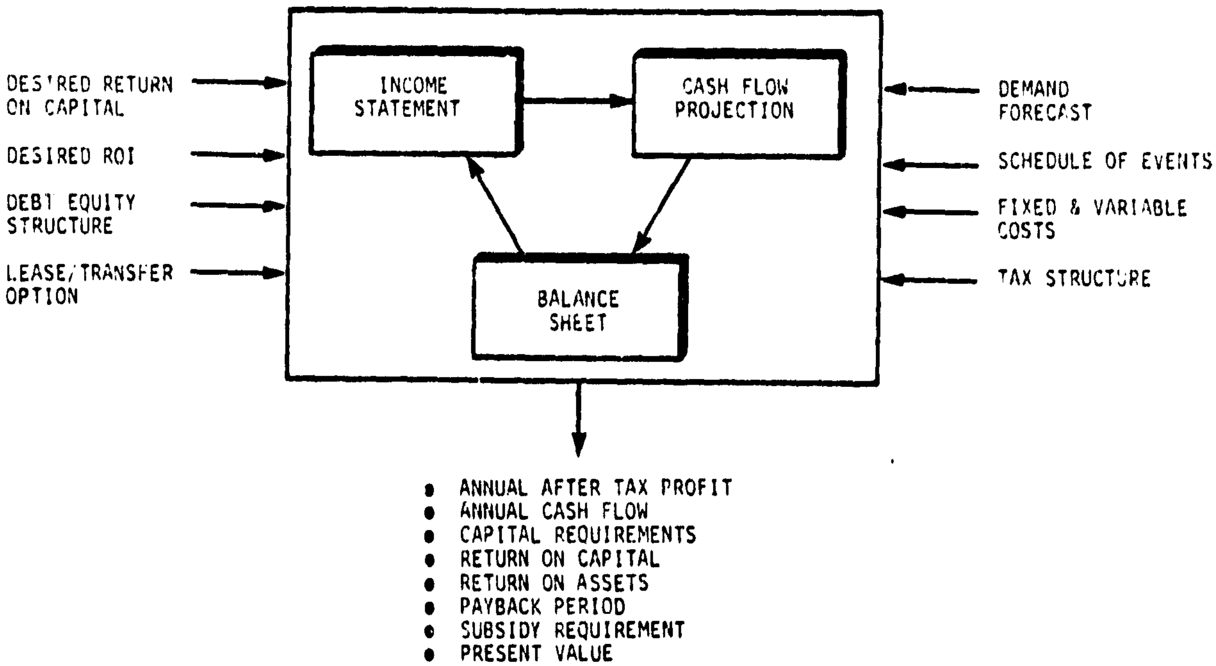


FIGURE 5.2 ANALYSIS OF PRIVATE OWNERSHIP AND OPERATION SCENARIO

As in the previous cases, government costs are also incurred. The annual government cost associated with the land remote sensing system may be expressed as follows:

Annual Fed. Gov't. Cost(I) = Gov't. Payment for Information Products(I) + Operations Costs(I) - Lease Payments(I) - Asset Recoupment Payments(I) - TDRSS Cost(I) + R&D Cost(I) - Profit Sharing or Royalty on Sales(I) + Subsidy Payments(I) + Interest on Debt(I) - Generated Tax Revenue(I).

Generated tax revenue consists, in this case, of two components—the first resulting from government expenditures in the private sector and the second resulting from the profitability of the commercial venture established for transfer of the remote sensing system. For the reasons previously discussed, the net effect of interest on debt and tax revenue (the first component) is assumed small and not quantified. All of the other costs and revenue items are presented in Section 6.2.

5.4 Phased Private Ownership (Government Ownership and Operation With Private Sector Marketing)

The phased private ownership scenario is based upon government ownership and operation of the space segment and the ground processing system, with the private sector venture concerned specifically with the marketing and sales of information products. This is basically the same as the government ownership and operation (continued ownership and operation) scenario as described in Section 5.2, with the exception that the marketing and sales operations are performed by the private sector. The interface is thus the provision of requested information products from the government to the marketing and sales organization. The marketing and sales organization will be granted an exclusive franchise to market and sell the information products to U.S. government agencies and nongovernment users. It would also market and sell to foreign users and would maintain the association with the foreign ground stations collecting the ground station fees.

For the provision of information products, the private venture makes payments to the government. It is assumed that these payments take the form of a royalty on sales with a minimum guaranteed annual payment made from the private sector to the government. The magnitude of this guarantee and the royalty percentage (competitively established) could serve as the basis for a competitively selected marketing and sales organization. The royalty payments would be made for information products having specified and agreed-to attributes. Guarantees

would have to be made by the government that these products would be available as agreed. Penalties would be imposed if the agreed-to information products were not provided.

From the private venture's point of view the guarantee level could be established such that the present value of net cash flow, including the guarantee payments, is equal to zero at a desired return on investment. This concept is illustrated in Figure 5.3.

This scenario has the apparent advantage of letting the private sector do what it knows best, i.e., marketing and sales. It requires the government to continue the ownership and operation of the remainder of the remote sensing system, in particular, those items necessitating large expenditures which the private sector may not be willing to make in any event without large subsidies.

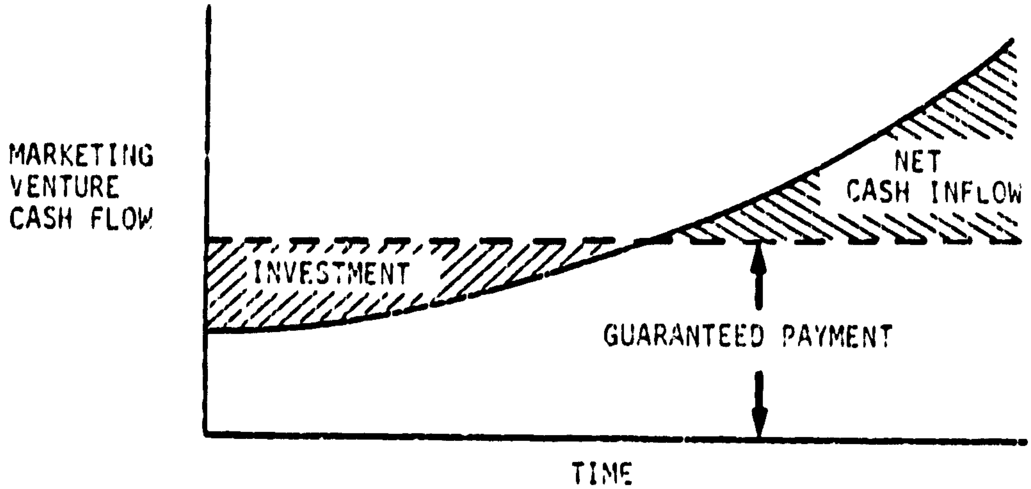
The annual government cost associated with the land remote sensing system may be expressed as follows:

Annual Fed. Gov't. Cost(I) = Gov't. Payments for Information Products(I)
+ Operations Costs(I) + R&D Cost(I)
- Profit Sharing or Royalty on Sales(I)
- Guaranteed Payments(I)
+ Interest on Debt(I) - Generated Tax Revenue(I).

As discussed in Section 5.3, the general tax revenue consists of two components. The first resulting from government expenditures in the private sector, and the second resulting from the profitability of the commercial venture. For the reasons previously discussed, the net effect of interest on debt and tax revenue (the first component) is assumed small and not quantified. All of the other cost and revenue items are quantified and are indicated in Section 6.3.

5.5 Legislatively-Chartered, Privately-Owned Corporation

From the financial analysis point of view the legislatively-chartered, privately-owned corporation is similar to the private ownership scenario discussed in Section 5.3. The major difference is concerned with the equity structure of the corporation. It is assumed that the federal government purchases equity in the corporation. This is in effect a form of subsidy. Altering the debt equity structure affects interest rates and the overall cost of capital. These effects are taken into account in the financial analysis and the results presented in Section 6.4.



GUARANTEED PAYMENT SUCH THAT.

PV OF INVESTMENT = PV OF NET CASH INFLOW
AT REQUIRED ROI

FIGURE 5.3 SCENARIO 4: PHASED PRIVATE OWNERSHIP (GOVERNMENT OWNERSHIP & OPERATION/PRIVATE SECTOR MARKETING)

As in the previous cases, government costs are also included. The annual government cost associated with the land remote sensing system may be expressed as follows:

Annual Fed. Gov't. Cost(I) = Gov't. Payment for Information Products(I)
+ Operations Costs(I) - Lease Payments(I)
- Asset Recoupment Payments(I)
- TDRSS Cost(I) + R&D Cost(I)
- Profit Sharing or Royalty on Sales(I)
+ Interest on Debt(I) - Generated Tax
Revenue(I) + Subsidy Payments(I)
+ Equity Purchase(I) - Dividends(I).

All of the cost and revenue items are quantified and are indicated in Section 6.4.

6. FINANCIAL ISSUES

As stated previously, we have taken the position that in order to evaluate the approaches for commercialization or retention it is necessary to plan potential business ventures and evaluate their financial merit, the likelihood of their financing and their impact on government cash flows. We have tried to play the role of an entrepreneur, putting together business plans for the purpose of obtaining financing. The business plans are based upon a perceived technology base, a market forecast, cost and capital expenditure estimates, and a specific business system. The market forecast is based upon a review of previous market studies and discussions with the user community. The cost and capital expenditure estimates were, in most cases, based upon estimated historical costs. No attempt was made to verify the accuracy of these cost data nor was an attempt made to address the issue of government overhead rates. With respect to the business scenario, from the large array of possibilities a particular scenario (as described in Section 3) was selected and used as the basis for planning and evaluating each of the approaches for commercialization or retention. This allows all of the approaches for commercialization or retention to be evaluated on a common basis and compared.

The analysis process followed is summarized in Figure 6.1. The first step was the formulation of the overall business plan which encompassed considerations of products, schedules, technology availability and nonfinancial issues. Ground segment costs and space segment costs were estimated. Ground segment costs were developed for processing, archiving and communications—both fixed and variable costs were developed. Space segment costs considered both nonrecurring and recurring costs and the phasing in of different sensors over time. The SATIL probabilistic life cycle costing model (see Appendix A) was used to verify estimates of the quantity of satellites required.

Demand and revenue forecasts were made in terms of information product type and market segment. A pricing policy was postulated and together with price elasticity estimates (by market segment and product type) were used in a Market Model to establish demand and revenue forecasts. The revenue forecasts together with the ground and space segment costs were used in the financial analysis (a financial analysis model was specifically developed for this purpose) to develop pro

ORIGINAL PAGE IS
OF POOR QUALITY

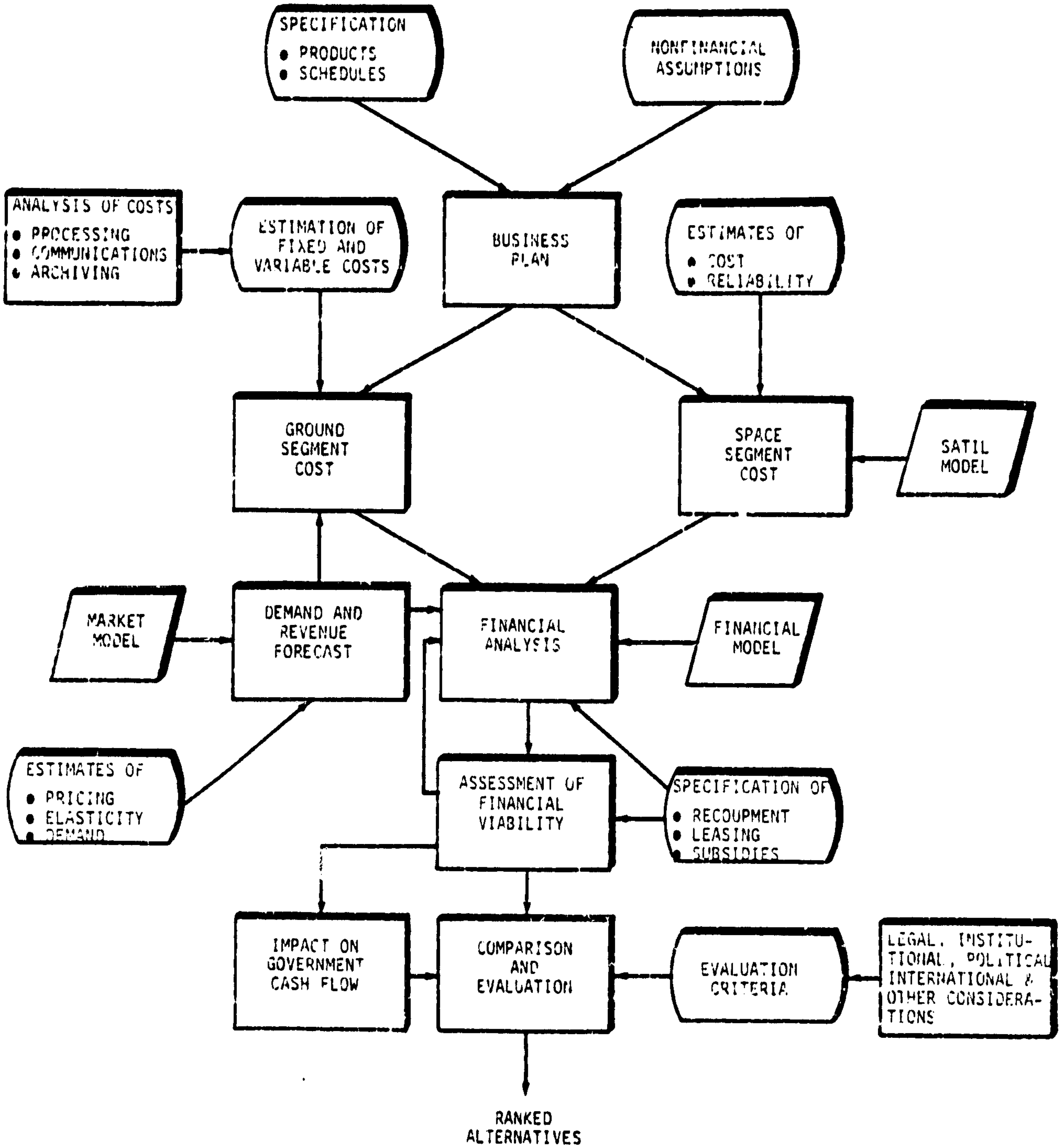


FIGURE 6.1 THE ANALYSIS PROCESS

forma income statements, cash flow projections and balance sheets for the commercial organizations. These financial analyses were iterated upon in order to establish the need for and the magnitude of government subsidies that would result in a viable business venture. Viability implies that the financial performance measures such as return on capital, return on assets and net present value are of sufficient magnitude to attract financing in the capital markets. The necessary financial performance measures were established by individuals with backgrounds in financing of large capital-intensive ventures. As a part of this effort alternative recoupment and leasing scenarios were considered.

Once a financially viable solution for each of the commercialization or retention scenarios was developed, the impact on government cash flow was determined. Nonfinancial issues together with the impact on government cash flows were considered in a comparison and ranking of the considered alternatives.

In the following paragraphs the results of the financial analyses, are presented and discussed. Detailed backup for the financial analyses (primarily with respect to the input data used in the analyses) is presented in Appendix B. Prior to presenting the results of the analyses, a brief discussion is presented with respect to the relationship and significance of the financial documentation and the criteria used for assessing financial viability.

6.1 Financial Projections for a Civil Land Remote Sensing System

The purpose of preparing financial projections is to provide the reader with information for making rational economic decisions with regard to five financial and organizational alternatives. Typically, financial statements are prepared to satisfy the needs of various user groups such as potential stockholders, creditors, government agencies, etc. Financial data provided to such user groups usually contains a Balance Sheet, Statement of Income and Statement of Changes in Financial Position. Additional information such as projected cash flows, return on equity, return on assets, debt to capitalization ratios and net present value of cash flows are provided as additional measurements used by the financial community to evaluate an enterprise. It should be emphasized that no single factor determines whether an enterprise is attractive or unattractive as an investment opportunity.

Contained in this section of the report are five separate sets of financial projections. These projections reflect the following financial and organizational approaches for commercialization or retention of the civil operational land remote sensing system:

1. Government ownership and operation (planned phase-out)
2. Government ownership and operation (continued ownership and operation)
3. Private ownership and operation
4. Phased private ownership (government ownership and operation with private sector marketing)
5. Legislatively-chartered, privately-owned corporation (government equity position).

As a separate and distinct land remote sensing enterprise does not currently exist, some historical data was not available as a basis for the projections. Therefore portions of the data used as a basis for the financial projections were estimated based upon the best information available at this time. The projections reflect, in our judgment, the single most probable result for each scenario projected. Each financial projection contains up to six parts as follows:

1. Data Set (applies with slight modifications to all scenarios)
2. Projected Statement of Income
3. Projected Balance Sheet
4. Projected Statement of Changes in Financial Position
5. Projected Cash Flow
6. Projected U.S. Government Cash Flows.

Part 1 - "Data Set" (Refer to Financial Exhibit 6.0)

In preparing a financial projection, as in preparing comparative projections, it is necessary to develop key basic assumptions upon which the projections are prepared. Although each scenario reflects alternative operating and capital assumptions, the basic assumptions with regard to costs and revenue are consistent in order to provide for an effective comparison. Supporting data to quantities used in the data set are contained in Appendix B of this report.

Direct costs reflected in the data set are semi-variable and variable costs attributed to processing, archiving and sales of remotely sensed data on a per scene basis. A learning factor and a processing to scenes factor is also applied. Although certain noncapital operating costs at EDC, Goddard and White Sands facilities are semi-variable, all costs have been treated as variable for purposes of this projection.

R&D and marketing costs are reflected in the data set as both a fixed minimum cost/year, as well as a percentage of revenue. This results in a semi-variable cost treatment dependent upon the projected revenue level. Communication costs for both TDRSS and DOMSAT have been treated as variable costs although certain costs are fixed. Variable and nonvariable ground facilities and equipment are assumed to be leased from the U.S. government through 1988 with alternative facilities and equipment leased from third parties after 1988. Fixed assets with the exception of LANDSAT D and D' have been depreciated on a four year straight line basis with full year depreciation taken in the year placed in service. LANDSAT D and D' are depreciated on a straight line basis over their remaining useful lives (one year and 3 years respectively).

Construction payment schedules for satellites generally assume a three to five year construction period with 12 percent of the total payment due four years before the satellite is delivered, 16 percent due three years before, 24 percent due two years before, 16 percent due one year before, and 32 percent due at launch. Construction payments include storage and cost of launch and are capitalized in the year incurred.

Cash requirements for Balance Sheet operating purposes are predicated upon an assumed number of days in terms of revenue for operating cash, accounts receivable and accounts payable. A fixed amount of contributed capital is reflected over the entire ten year projection with a cost of borrowing at an estimated 11 percent long-term borrowing rate.

Investment tax credits are taken on space segment assets during construction. It is assumed that 60 percent of annual R&D expenditures qualify for the R&D tax credit (a 60% x 25% R&D tax credit = 15% net credit). Royalties paid to the U.S. government are based upon a percentage of data sales with a minimum base royalty.

Part 2 - "Projected Statement of Income"

The Projected Statement of Income provides for the results of operations for the profit seeking alternative scenarios during a ten year period. The Income Statement and the derived cash flow may be considered to be the most important statement for purposes of evaluating the worth of the enterprise from the standpoint of investment value. Although a clear cut definition of an income statement is seldom found, one may simplistically describe it as a presentation of

revenue and cost predicated upon consistent accounting assumptions. The difference between revenues and costs derive net income which is used as a measure as to the financial success of the enterprise. A typical (simplified) profit and cash flow computation procedure is illustrated in Figure 6.2.

The Projected Statements of Income contained in this report were prepared consistent with the key assumptions reflected and described in the data set and Appendix B.

The before tax profit on operations is determined by subtracting the projected costs and expenses from the projected revenues. Federal taxes are deducted from the before tax profit at a rate of 51 percent. If the before tax profit is negative (a loss) the federal tax loss carry forward is treated as a benefit in the current year, reducing the reported loss. Current year investment and R&D tax credits are treated in the same manner. As this is not a cash inflow, adjustments are reflected on the cash flow statement.

Part 3 - "Projected Balance Sheet"

The Projected Balance Sheets presented depict the value of the various enterprises on the basis of projected revenues, costs, borrowings and contributed capital. Although the significance of a Projected Balance Sheet is not as important as a Projected Income Statement for making investment decisions, it is a valuable supplement to the information contained in the Statement of Income. More specifically, the Balance Sheet depicts the value of the enterprise in terms of assets, at cost, its liabilities and the equity of the shareholders at a given point in time.

Part 4 - "Projected Statement of Changes in Financial Position"

The Projected Statement of Changes in Working Capital reflects changes in the working capital of the enterprise from operating year to operating year. Working capital may be defined as current assets less current liabilities. The purpose of this statement is to provide an explanation of what provided working capital during each year and how working capital was applied during each year. In other words, the statement depicts whether or not sufficient working capital is provided by operations; if not, it indicates which sources are being utilized to provide working capital for continued operation of the enterprise.

Part 5 - "Projected Cash Flow"

This statement a) reflects sources of cash (net income, increases in current liabilities, etc.), b) applications of cash (losses, increases in fixed assets, accounts

ORIGINAL PAGE IS
OF POOR QUALITY

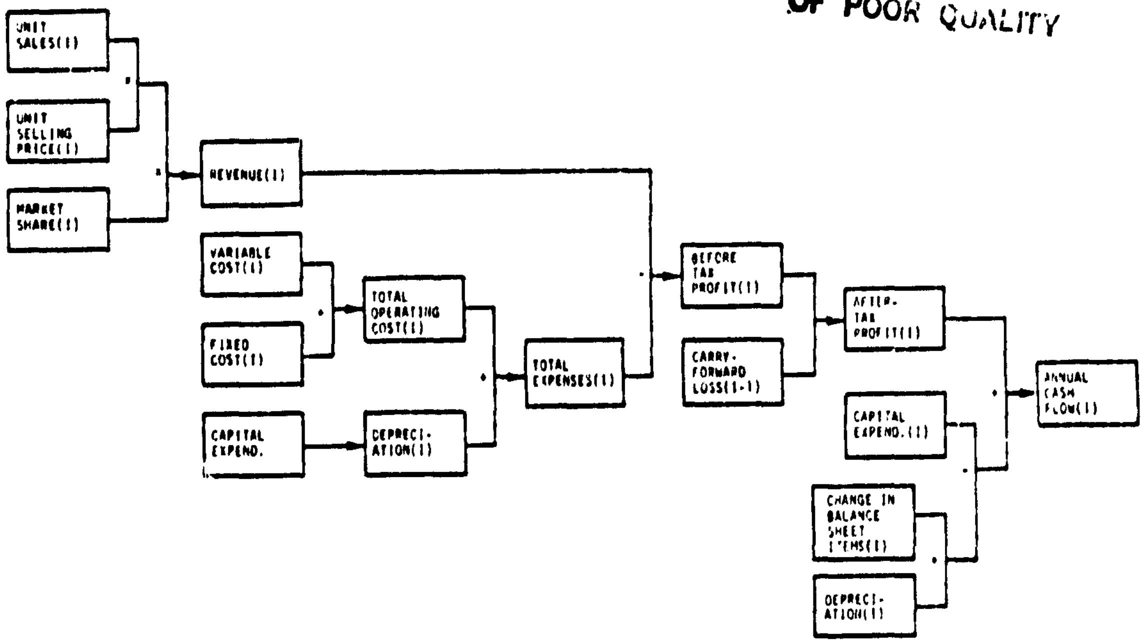


FIGURE 6.2 SIMPLIFIED PROFIT AND CASH FLOW COMPUTATIONAL PROCEDURE

receivable, etc.) The difference between the sources and applications is the net annual cash flow of the enterprise.

This statement is similar in nature to the Projected Statement of Changes in Financial Position except that operating funds are analyzed in terms of increases or decreases to cash from operations of the enterprise. Nonoperating sources of cash such as contributed capital and borrowed capital are not included. Nonoperating applications of cash such as dividend distributions are also excluded.

This statement also reflects adjustments for the noncash nature of the tax credits and loss carry forwards obtained in the early years of the venture. Although these credits were reflected on the Income Statement, Balance Sheet and Statement of Changes in Financial Position as credits in the year they were earned, no cash was actually received—credits would actually be carried forward and offset against future tax liabilities.

The cash flow stream is discounted at various rates and the present value of the venture is determined by summing the discounted values. Present value "A" is the sum of the discounted cash flows for the years 1985-1994. Present value "B" is the sum of the discounted cash flows from 1995 to infinity, assuming that the annual cash flow in each of those years is the same as it is projected to be in 1994.

Three key financial ratios of the venture are also shown. The return on capitalization is maintained at a value of 17 percent by adjustments to the "additional federal purchases" line. Capital market experts have indicated that a "utility" of this type should have the capability of maintaining at least this rate of return.

Part 6 - "Projected U.S. Government Cash Flows"

The cash flow described in the preceding section is that experienced by a commercial venture. Each of the five scenarios will result in a government cash flow impact. Dependent upon which scenario is examined the nature of the government cash flow will contain a subset of the following:

Cash outflows:

- Expenditures for information products, i.e., purchases of tapes and films
- Possible purchases of spacecraft and ground-based facilities
- Costs for operations such as spacecraft launches that exceed the actual reimbursement made to the federal government by the LANDSAT commercial venture
- Continuing government-funded research and development related to LANDSAT (assumed to be $10 million per year)
- Direct equity contributions from the U.S. government to the LANDSAT venture
- Any direct subsidy (also referred to as "additional federal purchases")

Cash inflows:

- Payments for leases of government facilities
- Any nongovernment data sales and ground station fees
- "Asset recoupment" means any initial payment made by the new venture when it takes over the existing LANDSAT assets
- Any royalty fees that may be paid by the venture to the government
- Tax revenues paid by the LANDSAT venture if it eventually becomes profitable and exhausts its tax loss carry forward credits
- Any dividends paid to the government if the government has become a stockholder.

6.1.1 Government Ownership and Operation (Planned Phase-Out) (Refer to Financial Exhibit 6.1)

Under this scenario revenues and associated costs are reflected through 1988 at which time LANDSAT D' ceases operation. No operating revenue is recognized beyond that time and all future costs of operating the land remote sensing system

are terminated. Federal purchases of remotely sensed data are assumed to be purchases from a third party at a cost consistent with amounts contained in the data set. As no private sector investment is reflected in this scenario, only government cash flows are projected.

Costs and revenues generated through termination are consistent with amounts reflected in the data set with the exception of ground station fees and government R&D expenditures. These amounts have been reduced as the program approaches the projected termination date.

6.1.2 Government Ownership and Operation (Continued Ownership and Operation) (Refer to Financial Exhibit 6.2)

This projection reflects a continued operation of the land remote sensing system by the U.S. government. Revenues and costs are consistent with those reflected in the data set. Assets, as well as other costs, have been treated on a cash basis. A $10 million/year R&D expenditure has been included as an assumed commitment by the government over the ten year period being projected.

Revenues by the government reflect nongovernment data sales and ground station fees consistent with amounts assumed in the data set. Interagency transfer payments for data sold are not included in government receipts.

As this financial projection does not assume private sector operations, the Projected Statement of Income, Balance Sheets, Statement of Changes in Financial Position and private sector Projected Cash Flows, have not been included.

6.1.3 Private Ownership and Operation (Refer to Financial Exhibits 6.3.1 through 6.3.5)

This financial projection assumes a divestiture of the land remote sensing system to a private sector enterprise. It is assumed that LANDSAT D and D' are purchased from the government by a private enterprise and that existing ground facilities are leased from the government for a four year period. All costs of operations are borne by the private entity. It is also assumed that costs of archiving are borne by the private sector. As the entity cannot derive a satisfactory rate of return on equity without federal assistance, "additional federal purchases" have been projected to derive a 17 percent return on equity to the private investor.

The financial statements are derived from base revenues and cost assumptions contained in the data set. Tax benefits and costs are reflected on a current year basis. Although the space segment assets qualify as five year ACRS property

for depreciation for tax purposes, asset lives of four years were used in the financial projections. Such timing differences have not been reflected in the benefit calculations and are not considered to have a material effect.

Variables are reflected in the long-term debt and cumulative dividends amounts contained in the Projected Balance Sheets. Excess cash "thrown off" by the venture, in excess of assumed long-term debt of $100 million, are treated as distribution of dividends.

The Projected Cash Flow provides for a discounted rate of return of approximately 12 percent with a return on equity of 17 percent. Return on assets and debt to capitalization ratios are also provided.

6.1.4 Phased Private Ownership (Private Sector Marketing) (Refer to Financial Exhibits 6.4.1 through 6.4.5)

The financial projections for phased private ownership reflect a separate marketing organization established with exclusive rights for sales of U.S.-produced land remote sensed data produced by the LANDSAT venture. Initially (first ten years) all costs of operation would be borne by the U.S. government. In return for such rights, the private sector would pay a minimum royalty fee of 80 percent of all data sold and ground station fees with a minimum annual royalty payment (guaranteed) of $33.5 million. Cash generated by the venture in excess of operating requirements are first used to reduce long-term debt and next used to provide dividends to the private investor. A rate of return based upon present value of cash flows for the first ten years is calculated at 12 percent to 13 percent. Other ratios such as return on assets, return on equity and debt to capitalization are calculated based upon the present value of cash flow assumption of 12 percent to 13 percent over the first ten years. Government cash flows reflect the costs of continued operation reduced by royalty fees collected and tax revenues received from the private sector enterprise.

6.1.5 Legislatively-Chartered, Privately-Owned Corporation (Refer to Financial Exhibits 6.5.1 through 6.5.5)

The financial projection for this organizational scenario closely reflects private ownership (Section 6.1.3) with the addition of an equity participation by the U.S. government. The government would provide initial equity capital which was assumed to be a 33 percent participation. Dividend distributions from the enterprise provided in later years would be paid to the government based upon its equity participation. No provision has been made in the projection for the government liquidating its equity position in the venture at any time.

6.1.6 Comparison of Financial Projections

In comparing projected operating results of the five financial and organizational scenarios, it is appropriate to evaluate such alternatives from both a public and private sector viewpoint. It appears that the existing civil remote sensing system is not a viable commercial enterprise without either a significant guaranteed subsidy by the U.S. government or a material reduction in the projected costs of operation. Government costs for the continuation of the existing land remote sensing system range from an average annual cost of $68 million (constant FY83$) per year for government operation to $82 million (constant FY83$) per year under a private ownership alternative (Figure 6.3). If the private sector alternative is chosen, a minor reduction in cost to government may be achieved through transfer of existing LANDSAT program assets to the private sector without recoupment by the government (Figure 6.4). Assuming continuation of the system is desired, continued government operation reflects the lowest projected cost. The primary reason for continued government operation be the most cost effective alternative is that return on capital costs are not considered in the evaluation of government costs of operation. To attract private sector investment in an enterprise, a reasonable rate of return must be achieved. In order for a private sector alternative to provide a lower cost to the government (subsidy), cost and/or revenue efficiencies by the private sector would have to improve significantly to offset required return on capital.

The financial analysis in this report is predicated upon a consistent set of data with regard to revenues and costs for both private sector operation as well as continued operation by the government. A specific level of service was assumed. It should be noted that system configurations which provided other levels of service were not analyzed. It is possible that such systems may provide a lower cost to the government but would result in reduced services and benefits.

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985 1994
COMPARATIVE ANALYSIS OF
NET GOVERNMENT EXPENDITURES

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS, 6% INFLATION RATE ASSUMED

FISCAL YEAR	GOVERNMENT OWNERSHIP AND OPERATION (PLANNED PHASE-OUT)	GOVERNMENT OWNERSHIP AND OPERATION (CONT'D OWNERSHIP & OPERATION)	PRIVATE OWNERSHIP AND OPERATION	PHASED PRIVATE SECTOR OWNERSHIP (PRIVATE SECTOR MKTG.)	LEGISLATIVELY CHARTERED, PRIVATELY OWNED CORPORATION
1985	58,935	96,855	-130,855	90,061	-106,105
1986	15,544	112,346	132,396	111,764	132,396
1987	16,076	156,846	170,422	160,181	170,422
1988	14,120	69,456	115,802	74,905	115,802
1989	14,300	97,104	137,365	163,554	137,365
1990	14,340	108,921	173,685	114,216	173,685
1991	17,850	131,510	177,438	137,412	177,438
1992	20,980	50,471	187,498	57,163	187,498
1993	24,310	73,726	167,605	60,904	129,675
1994	27,340	51,219	146,543	59,165	127,672
NET PRESENT VALUE @ 10%:					
YEARS 1-10	144,917	610,037	686,777	628,763	686,170
YEAR 11 AND AFTER	95,825	179,866	513,623	207,369	447,481
TOTAL NET PRESENT VALUE	240,742	789,903	1,200,400	836,132	1,133,651

FIGURE 6.3 COMPARISON OF NET GOVERNMENT EXPENDITURES

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
COMPARATIVE ANALYSIS
ASSET RECOUPMENT BY THE U.S. GOVERNMENT VS.
NONRECOUPMENT BY THE U.S. GOVERNMENT*

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS, AT INFLATION RATE ASSUMED

FISCAL YEAR	RECOUPMENT OF ASSETS BY U.S. GOVERNMENT				NONRECOUPMENT OF ASSETS BY U.S. GOVERNMENT			
	PRIVATE OWNERSHIP & OPERATION		LEGISLATIVELY CHARTERED, PRIVATELY OWNED CORPORATION		PRIVATE OWNERSHIP & OPERATION		LEGISLATIVELY CHARTERED, PRIVATELY OWNED CORPORATION	
	NET GOV'T. EXPENDITURES	ADDITIONAL FED. PURCHASES	NET GOV'T. EXPENDITURES	ADDITIONAL FED. PURCHASES	NET GOV'T. EXPENDITURES	ADDITIONAL FED. PURCHASES	NET GOV'T. EXPENDITURES	ADDITIONAL FED. PURCHASES
1985	-130,855	160,000	-106,105	160,000	49,961	37,500	74,711	37,500
1986	132,396	142,500	132,396	142,500	48,796	35,000	48,796	35,000
1987	170,422	180,000	170,422	180,000	94,322	80,000	94,322	80,000
1988	115,802	125,000	115,802	125,000	96,124	97,500	96,124	97,500
1989	137,365	120,000	137,365	120,000	121,783	120,000	121,783	120,000
1990	173,685	155,000	173,685	155,000	153,524	155,000	153,524	155,000
1991	177,438	180,000	177,438	180,000	176,821	180,000	176,821	180,000
1992	187,498	215,000	187,498	215,000	186,648	215,000	186,848	215,000
1993	167,005	175,000	129,675	175,000	163,869	170,000	122,895	170,000
1994	146,543	155,000	127,672	155,000	144,093	150,000	126,030	150,000
NET PRESENT VALUE @ 10% YEARS 1-10	686,777	972,484	686,170	972,484	687,497	674,315	684,712	674,315
YEAR 11 & AFTER	513,623	543,266	447,481	543,266	505,036	525,741	441,727	525,741
TOTAL NET PRESENT VALUE	1,200,400	1,515,750	1,133,651	1,515,750	1,192,533	1,200,056	1,126,439	1,200,056

*RECOUPMENT OF ASSETS DEFINED AS PAYMENT BY ENTERPRISE TO U.S. GOVERNMENT FOR LANDSAT D & D', AND LEASE PAYMENTS FOR USE OF GSFC FACILITIES.

FIGURE 6.4 COMPARISON OF ASSET RECOUPMENT BY THE U.S. GOVERNMENT VS. NONRECOUPMENT BY THE U.S. GOVERNMENT

ORIGINAL PAGE IS OF POOR QUALITY

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
DATA SET
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED
UNITS EXPRESSED IN THOUSANDS
AMOUNTS PER SCENE EXPRESSED IN WHOLE DOLLAR AMOUNTS

REVENUE/COST ELEMENT	FISCAL YEARS 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
REVENUE:										
UNITS SOLD										
80 METER---FILM	42.79 (1)*	40.32	37.14	34.48	32.00	31.10	28.63	27.94	27.94	27.94
TAPE	11.45 (1)	10.25	9.73	10.60	10.18	9.81	9.28	8.60	7.91	7.91
30 METER---FILM	16.50 (1)	24.11	25.28	21.62	19.41	13.66	18.88	23.42	25.70	27.17
TAPE	2.35 (1)	3.50	3.79	3.32	2.97	2.07	3.03	3.65	3.92	4.07
SALES-FEDERAL-----80M	6540 (1)	7280	8010	8790	9570	10320	11240	11900	12560	13430
NON-FEDERAL 80M	3490 (1)	3100	3220	4930	5180	5630	6280	5440	4540	4830
FEDERAL-----30M	3640 (1)	5850	6240	5330	4730	4020	6610	9040	11650	13910
NON-FEDERAL 30M	4300 (1)	6660	8040	7900	7780	5340	8910	12130	13210	14340
STATION FEE/FOREIGN STATION	672 (1)	712	755	800	848	899	953	1010	1071	1135
NO. OF FOREIGN STATIONS	13 (1)	14	15	15	15	15	15	15	15	15
OTHER REVENUE	0	0	0	0	0	0	0	0	0	0
ADDITIONAL FEDERAL PURCHASES	160000 (2)	142500	180000	125000	120000	155000	180000	215000	175000	155000
DIRECT COSTS:										
PROCESSING COST/SCENE-80M	270.30 (3)	286.50	303.70	321.90	341.20	361.70	383.30	406.30	430.70	456.60
30M	495.80 (4)	525.55	557.08	590.51	625.94	663.49	703.30	745.50	790.23	837.64
PROCESSING LEARNING FACTOR	1.00 (5)	0.90	0.85	0.81	0.78	0.76	0.74	0.73	0.72	0.70
PROCESSING/SALES FACTOR	0.52 (6)	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
ARCHIVAL COST/SCENE 80M	49.70 (7)	52.70	55.80	59.20	62.70	66.50	70.50	74.70	79.20	83.90
30M	121.80 (8)	129.10	136.80	145.00	153.80	163.00	172.70	183.10	194.10	205.70
ARCHIVAL LEARNING FACTOR	1.00 (9)	0.90	0.85	0.81	0.78	0.76	0.74	0.73	0.72	0.70
COST OF SALES/UNIT 80M-FILM	30.30 (10)	32.10	34.00	36.10	38.20	40.50	43.00	45.50	48.30	51.10
TAPE	182.60 (10)	193.60	205.20	217.50	230.50	244.30	259.00	274.50	291.00	308.40
30M-FILM	53.10 (10)	56.30	59.70	63.20	67.00	71.00	75.30	79.80	84.60	89.70
TAPE	319.60 (10)	338.80	359.10	380.60	403.50	427.70	453.30	480.50	509.30	539.90
C OF S LEARNING FACTOR	1.00 (11)	0.90	0.85	0.81	0.78	0.76	0.74	0.73	0.72	0.70
INDIRECT LABOR	5009 (12)	5310	5628	5966	6324	6703	7105	7532	7984	8463
R&D-EXPRESSED IN DOLLARS	900 (13)	950	1010	1070	1135	1200	1275	1350	1430	1520
-EXPRESSED AS % OF REV	0.04 (13)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
MARKETING,ADV,&PROMOTION										
EXPRESSED IN DOLLARS	1425 (14)	1510	1600	1700	1800	1900	2025	2150	2275	2400
EXPRESSED AS % OF REV	0.05 (14)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
COMMUNICATIONS COSTS:										
TDRSS COST/SCENE 80M	62.50 (15)	66.30	70.20	74.40	78.90	83.60	88.60	93.90	99.60	105.50
30M	354.20 (15)	375.50	398.00	421.80	447.20	474.00	502.40	532.50	564.50	598.40
DOMSAT COST/SCENE 80M	10.40 (16)	11.00	11.70	12.40	0.00	0.00	0.00	0.00	0.00	0.00
30M	6.70 (16)	7.10	7.53	7.98	8.46	8.97	9.50	10.07	10.68	11.32
TDRSS LEASE COSTS(ANNUAL)	6.00 (17)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DOMSAT LEASE COSTS(ANNUAL)	0.00 (18)	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LEASE COSTS:										
LANDSAT D	0 (19)		0	0	0	0	0	0	0	0
LANDSAT D'	0 (19)	0	0	0	0	0	0	0	0	0
GROUND FACILITIES-GSFC	23900 (20)	23900	23900	23900	0	0	0	0	0	0
EDC	2200 (20)	2200	2200	2200	0	0	0	0	0	0
W. SANDS	0 (20)	0	0	0	0	0	0	0	0	0
NON-GOVT	0 (20)	0	0	0	23120	23120	23120	23120	23120	23120

FINANCIAL EXHIBIT 6.0 DATA SET

*THE NUMBER IN PARENTHESIS REFER TO SECTIONS IN APPENDIX B WHEREIN SUPPORTING DOCUMENTATION WILL BE FOUND.

ORIGINAL PAGE IS OF POOR QUALITY

ASSETS:											
GROUND SEGMENT:											
GROUND STATION		0 (21)	0	0	0	0	0	0	0	0	0
PROCESSING FACILITIES		0 (21)	0	0	0	0	0	0	0	0	0
ADDITIONAL FACILITIES		0 (21)	0	0	0	0	0	0	0	0	0
CUMULATIVE GROUND SEGMENT		0 (21)	0	0	0	0	0	0	0	0	0
SPACE SEGMENT:											
LANDSAT D	71700 (23)	71700									
LANDSAT D'	248000 (23)	248000	0	0	0	0	0	0	0	0	0
LANDSAT E	172000 (23)	25800	65360	80840	0	0	0	0	0	0	0
LANDSAT E'	101000 (23)	12120	29290	17170	0	0	42420	0	0	0	0
LANDSAT F	241000 (23)	0	0	28920	38560	57840	38560	77120	0	0	0
LANDSAT F'	149000 (23)	0	0	14900	19370	29800	19370	14900	0	0	0
LANDSAT G & G'	275000 (23)	0	0	0	0	0	0	33000	44000	66000	44000
CUMULATIVE SPACE SEGMENT		357620	452270	594100	652030	739670	840020	965040	1009040	1075040	1119040
DEPRECIABLE LIFE (STRAIGHT LINE)											
GROUND STATION&FACILITIES		4YRS									
LANDSAT D		1YRS									
LANDSAT D'		3YRS									
LANDSAT E		4YRS									
LANDSAT E'		4YRS									
LANDSAT F		4YRS									
LANDSAT F'		4YRS									
LANDSAT G & G'		4YRS									
CONSTRUCTION IN PROCESS:											
% OF COMPLETION/YEAR											
LANDSAT D'		1.00									
LANDSAT E		0.15	0.38	0.47							
LANDSAT E'		0.12	0.29	0.17	0.00	0.00	0.42				
LANDSAT F				0.12	0.16	0.24	0.16	0.32			
LANDSAT F'				0.10	0.13	0.20	0.13	0.10			
LANDSAT G & G'								0.12	0.16	0.24	0.16
DEPRECIATION EXPENSE											
GROUND STATION		0	0	0	0	0	0	0	0	0	0
PROCESSING FACILITIES		0	0	0	0	0	0	0	0	0	0
ADDITIONAL FACIL & EQUIP		0	0	0	0	0	0	0	0	0	0
LANDSAT D		71700	0	0	0	0	0	0	0	0	0
LANDSAT D'		78533	78533	78533	0	0	0	0	0	0	0
LANDSAT E		0	0	40850	40850	40850	40850	0	0	0	0
LANDSAT E'		0	0	0	0	0	23988	23988	23988	23988	0
LANDSAT F		0	0	0	0	0	0	57238	57238	57238	57238
LANDSAT F'		0	0	0	0	0	0	0	0	0	0
LANDSAT G & G'		0	0	0	0	0	0	0	0	0	0
CUMULATIVE DEPRECIATION		150233	228767	348150	389000	429850	494687	575912	657137	738362	795600
CASH REQ IN DAYS		15 (24)	15	15	15	15	15	15	15	15	15
A/R REQ IN DAYS		60 (25)	60	60	60	60	60	60	60	60	60
C/L REQ IN DAYS		30 (26)	30	30	30	30	30	30	30	30	30
DAYS IN YEAR		365	365	365	365	365	365	365	365	365	365
CONTRIBUTED CAPITAL		75000 (27)	75000	75000	75000	75000	75000	75000	75000	75000	75000
COST OF BORROWING	0.11	0.11 (28)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
FEDERAL AND STATE TAX RATE		0.51 (29)	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51
INVESTMENT TAX CREDIT BASE		357620 (30)	94650	141830	57930	87[illegible]40	100350	125020	44000	66000	44000
INVESTMENT TAX CREDIT RATE		0.10 (31)	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
EQUITY PARTICIPATION BY USG		0.33 (32)	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
R&D TAX CREDIT RATE		0.15 (33)	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
OTHER EXPENSES											
ROYALTIES-BASE FEE		33500 (34)	0	0	0	0	0	0	0	0	[illegible]
ROYALTIES AS A % OF SALES		0.80 (35)	0.60	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
U.S. GOVERNMENT R&D EXPENDIT		10000 (36)	10000	10000	10000	10000	10000	10000	10000	10000	10000

FINANCIAL EXHIBIT 6.0 DATA SET (CONTINUED)

ORIGINAL PAGE IS OF POOR QUALITY

SCENARIO # 1
GOVERNMENT OWNERSHIP AND OPERATION
(PLANNED PHASE OUT)

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED U.S. GOVERMENT CASH FLOWS
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
U.S. GOVERMENT EXPENDITURES:										
INFORMATION PRODUCTS	0	0	0	14120	14300	14340	17850	20980	24310	27340
ASSET PURCHASES	46000	0	0	0	0	0	0	0	0	0
OPERATIONS COSTS(NET OF RE- IMBURSEMENTS	25461	27424	27601	0	0	0	0	0	0	0
R&D COSTS	10000	5000	2000	0	0	0	0	0	0	0
EQUITY CONTRIBUTION	0	0	0	0	0	0	0	0	0	0
SUBSIDY	0	0	0	0	0	0	0	0	0	0
TOTAL US GOV'T EXPENDITURES	75461	32424	29601	14120	14300	14340	17850	20980	24310	27340
U.S. GOVERNMENT RECEIPTS:										
RECEIPTS FROM LEASE(GRD FAC)	0	0	0	0	0	0	0	0	0	0
NON-GOVERMENT DATA SALES AND GROUND STATION FEES	16526	16880	13525	0	0	0	0	0	0	0
ASSET RECOUPMENT	0	0	0	0	0	0	0	0	0	0
TDRSS USEAGE FEES	0	0	0	0	0	0	0	0	0	0
ROYALTY FEES	0	0	0	0	0	0	0	0	0	0
TAX REVENUE	0	0	0	0	0	0	0	0	0	0
DIVIDENDS RECEIVED	0	0	0	0	0	0	0	0	0	0
TOTAL US GOV'T RECEIPTS	16526	16880	13525	0	0	0	0	0	0	0
NET US GOV'T EXPENDITURES	58935	15544	16076	14120	14300	14340	17850	20980	24310	27340

DISCOUNT RATE	PRESENT VALUE "A"	PRESENT VALUE "B"	TOTAL PRESENT VALUE
0.10	144917	95825	240742
0.15	122191	39177	161368
0.20	105557	18398	123955
0.25	93017	9394	102411
0.30	83308	5085	88393

PRESENT VALUE OF "A" IS THE PRESENT VALUE OF THE CASH FLOWS, YEAR 1 THROUGH 10
PRESENT VALUE OF "B" IS THE PRESENT VALUE OF THE CASH FLOWA, YEAR 11 AND AFTER

FINANCIAL EXHIBIT 6.1 GOVERNMENT OWNERSHIP AND OPERATION (PLANNED PHASE-OUT)

SCENARIO # 2
GOVERNMENT OWNERSHIP AND OPERATION
(CONTINUED OWNERSHIP AND OPERATION)

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED U.S. GOVERMENT CASH FLOWS
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS									
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
U.S. GOVERMENT EXPENDITURES:										
INFORMATION PRODUCTS	0	0	0	0	0	0	0	0	0	0
ASSET PURCHASES	77920	94650	141830	57930	87640	100350	125020	44000	66000	44000
OPERATIONS COSTS(NET OF RE- IMBURSEMENTS	25461	27424	27601	26356	25144	23026	25975	29191	31541	33513
R&D COSTS	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
EQUITY CONTRIBUTION	0	0	0	0	0	0	0	0	0	0
SUBSIDY	0	0	0	0	0	0	0	0	0	0
TOTAL US GOV'T EXPENDITURES	113381	132074	179431	94286	122784	133376	160995	83191	107541	87513
U.S. GOVERNMENT RECEIPTS:										
RECEIPTS FROM LEASE(GRD FAC)	0	0	0	0	0	0	0	0	0	0
NON-GOVERMENT DATA SALES AND GROUND STATION FEES	16526	19728	22585	24830	25680	24455	29485	32720	33815	36195
ASSET RECOUPMENT	0	0	0	0	0	0	0	0	0	0
TDRSS USEAGE FEES	0	0	0	0	0	0	0	0	0	0
ROYALTY FEES	0	0	0	0	0	0	0	0	0	0
TAX REVENUE	0	0	0	0	0	0	0	0	0	0
DIVIDENDS RECEIVED	0	0	0	0	0	0	0	0	0	0
TOTAL US GOV'T RECEIPTS	16526	19728	22585	24830	25680	24455	29485	32720	33815	36195
NET US GOV'T EXPENDITURES	96855	112346	156846	69456	97104	108921	131510	50471	73726	51318

DISCOUNT RATE	PRESENT VALUE "A"	PRESENT VALUE "B"	TOTAL PRESENT VALUE
0.10	610037	179866	789904
0.15	506960	73536	580496
0.20	429511	34534	464045
0.25	369964	17633	387597
0.30	323229	9545	332774

PRESENT VALUE OF "A" IS THE PRESENT VALUE OF THE CASH FLOWS, YEAR 1 THROUGH 10
PRESENT VALUE OF "B" IS THE PRESENT VALUE OF THE CASH FLOWS, YEAR 11 AND AFTER

FINANCIAL EXHIBIT 6.2 GOVERNMENT OWNERSHIP AND OPERATION (CONTINUED OWNERSHIP AND OPERATION)

ORIGINAL PAGE IS OF POOR QUALITY

PRIVATE OWNERSHIP AND OPERATION

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED STATEMENT OF INCOME
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

FISCAL YEARS	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
REVENUE										
DATA-FEDERAL	10180	13130	14250	14120	14300	14340	17850	20980	24310	27340
-NON-FEDERAL	7790	9760	11260	12830	12960	10970	15190	17570	17750	19170
FOREIGN STATION FEES	8736	9968	11325	12000	12720	13485	14295	15150	16065	17025
OTHER REVENUE	0	0	0	0	0	0	0	0	0	0
ADDITIONAL FEDERAL PURCHASE	160000	142500	180000	125000	120000	155000	180000	215000	175000	155000
TOTAL REVENUE	186706	175358	216835	163950	159980	193795	227335	268700	233125	218535
DIRECT COSTS:										
PROCESSING	12483 (37)	*13571	13450	12326	11520	9972	11520	13299	14545	15482
ARCHIVAL	2596 (37)	2915	2914	2549	2469	2088	2484	2916	3216	3434
SALES	5014 (37)	5238	5210	5020	4733	4189	4757	5300	5633	5951
ROYALTIES	0	0	0	0	0	0	0	0	0	0
TOTAL DIRECT COSTS	20093	21724	21573	19995	18722	16249	18761	21517	23393	24866
GROSS MARGIN	166613	153634	195262	143955	141258	177546	208574	247183	209732	193669
OTHER OPERATING COSTS.										
INDIRECT COSTS	5069	5310	5628	5966	6324	6703	7105	7532	7984	8463
RESEARCH & DEVELOPMENT	1068	1314	1473	1558	1599	1552	1893	2149	2325	2541
ADVERTISING & PROMOTION	1425	1643	1842	1948	1999	1940	2367	2685	2906	3177
COMMUNICATIONS COST:										
-TDRSS	5235 (38)	7134	7728	7218	6935	5655	7479	9284	10552	11686
-DOMSAT	357 (38)	391	399	395	98	73	108	142	164	184
LEASE COSTS-GROUND SEGMENT	26100	26100	26100	26100	23120	23120	23120	23120	23120	23120
SPACE SEGMENT	0	0	0	0	0	0	0	0	0	0
DEPRECIATION-GROUND SEGMENT	0	0	0	0	0	0	0	0	0	0
-SPACE SEGMENT	150233	78533	119383	40850	40850	64878	81225	81225	81225	57238
INTEREST	18653	15378	14973	15465	13567	15149	15231	15321	5569	11000
OTHER EXPENSES	0	0	0	0	0	0	0	0	0	0
TOTAL INDIRECT EXPENSES	208082	135804	177527	99499	94493	119030	138520	141456	133845	117408
BEFORE TAX PROFIT-OPERATIONS	-41469	17831	17735	44456	46765	58516	70055	105727	75887	76260
INTEREST INCOME	0	0	0	0	0	0	0	0	0	0
BEFORE TAX PROFIT-OPERATIONS	-41469	17831	17735	44456	46765	58516	70055	105727	75887	76260
PROVISION FOR FEDERAL TAXES	21149	-9094	-9045	-22673	-23850	-29843	-35728	-53921	-38702	-38893
INVESTMENT TAX CREDIT	35762	9465	14183	5793	8764	10035	12502	4400	6600	4400
R&D TAX CREDIT	160	197	221	234	240	233	284	322	349	381
NET INCOME	15603	18399	23094	27810	31919	38941	47113	56528	44133	42149

FINANCIAL EXHIBIT 6.3.1 PRIVATE OWNERSHIP AND OPERATION

*SEE APPENDIX B.

PRIVATE OWNERSHIP AND OPERATION

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED BALANCE SHEETS
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

FISCAL YEARS	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
ASSETS										
FIXED ASSETS:										
GROUND SEGMENT	0	0	0	0	0	0	0	0	0	0
SPACE SEGMENT	357620	452270	594100	652030	739670	840020	965040	1009040	1075040	1119040
TOTAL FIXED ASSETS	357620	452270	594100	652030	739670	840020	965040	1009040	1075040	1119040
LESS:ACCUMULATED DEPRECIATION	150233	228767	348150	389000	429850	494687	575712	657137	738362	795600
NET FIXED ASSETS	207387	223503	245950	263030	309820	345333	389128	351903	336678	323440
CURRENT ASSETS	38364	36032	44555	33688	32873	39821	46713	55212	47902	44904
OTHER CURRENT ASSETS	0	0	0	0	0	0	0	0	0	0
TOTAL ASSETS	245751	259536	290505	296718	342693	385153	435840	407115	384580	368344
CAPITALIZATION AND LIABILITIES										
CAPITALIZATION:										
CONTRIBUTED CAPITAL	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000
RETAINED EARNINGS	15603	34002	57096	84906	116825	155765	202878	259406	303539	345688
CUMULATIVE DIVIDENDS PAID	0	0	0	0	0	0	0	0	-113120	-170305
TOTAL CAPITALIZATION	90603	109002	132096	159906	191825	230765	277878	334406	265419	250383
LONG-TERM DEBT	139803	136121	140587	123337	137719	138460	139277	50624	100000	100000
CURRENT LIABILITIES	15346	14413	17822	13475	13149	15928	18685	22085	19161	17962
TOTAL LIABILITIES	155148	150534	158409	136813	150868	154388	157962	72709	119161	117962
TOTAL LIAB AND CAPITALIZATION	245751	259536	290505	296718	342693	385153	435840	407115	384580	368344

FINANCIAL EXHIBIT 6.3.2 PRIVATE OWNERSHIP AND OPERATION

ORIGINAL PAGE IS OF POOR QUALITY

PRIVATE OWNERSHIP AND OPERATION

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED STATEMENT OF CHANGES
IN FINANCIAL POSITION
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS									
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
USES OF WORKING CAPITAL:										
NET LOSS	0	0	0	0	0	0	0	0	0	0
ITEMS WHICH DO NOT PROVIDE (USE) WORKING CAPITAL:										
DEPRECIATION AND AMORT	-150233	-78533	-119383	-40850	-40850	-64838	-81225	-81225	-81225	-57238
WORKING CAP APPLIED TO OPER	-150233	-78533	-119383	-40850	-40850	-64838	-81225	-81225	-81225	-57238
PAYMENT OF DIVIDENDS	0	0	0	0	0	0	0	0	113120	57185
ADDITIONS TO EQUIPMENT	357620	94650	141830	57920	87640	100350	125020	44000	66000	44000
REDUCTION IN L.T. DEBT	0	3682	0	17250	0	0	0	88653	0	0
INCREASE IN WORKING CAPITAL	23019	0	5114	0	0	4169	4175	5100	0	0
	230405	19798	27560	34330	46790	39681	47930	56528	97895	43947
SOURCES OF WORKING CAPITAL:										
NET INCOME	15603	18399	23094	27810	31919	38941	47113	56528	44133	42149
PROCEEDS FROM SALE OF C/S	75000									
PROCEEDS FROM L.T. DEBT	139803	0	4466	0	14382	741	817	0	49376	0
DECREASE IN WORKING CAPITAL	0	1399	0	6520	489	0	0	0	4386	1799
	230405	19798	27560	34330	46790	39681	47930	56528	97895	43947
CHANGES TO WORKING CAPITAL:										
INCREASE(DECREASE) TO CURRENT ASSETS	38364	-2332	8523	-10867	-816	6948	6892	8500	-7310	-2998
INCREASE(DECREASE) TO CURRENT LIABILITIES	15346	-933	3409	-4347	-326	2779	2757	3400	-2924	-1199
INCREASE(DECREASE) IN WORKING CAPITAL	23019	-1399	5114	-6520	-489	4169	4175	5100	-4386	-1799

FINANCIAL EXHIBIT 6.3.3 PRIVATE OWNERSHIP AND OPERATION

PRIVATE OWNERSHIP AND OPERATION

(DIVIDEND DISTRIBUTIONS NOT INCLUDED)

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED CASH FLOW
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
APPLICATIONS OF CASH:										
NET LOSS	0	0	0	0	0	0	0	0	0	0
ITEMS WHICH DO NOT PROVIDE CASH:										
DEPRECIATION	150233	78533	119383	40850	40850	64838	81225	81225	91225	57138
ADDITIONS TO FIXED ASSETS	-357620	-94650	-141830	-57930	-87640	-100350	-125020	-44000	-66000	-44000
INCREASE IN ACCOUNTS REC	-30691	1865	-6818	8693	653	-5559	-5513	-6800	5848	2398
TAX ADJUSTMENT	-57071	-569	-5359	16646	14846	19575	22942	49198	31754	34111
TOTAL APPLICATIONS OF CASH	-295149	-14820	-34624	8259	-31291	-21496	-26367	79624	52827	49747
SOURCES OF CASH:										
NET INCOME	15603	18399	23094	27810	31919	38941	47113	56528	44133	42149
INCREASE IN CURRENT LIAB.	15346	-933	3409	-4347	-326	2779	2757	3400	-2924	-1199
TAX ADJUSTMENT	0	0	0	0	0	0	-22942	-49198	-31754	-34111
TOTAL SOURCES OF CASH	30948	17466	26503	23463	31592	41720	26928	10730	9456	6838
CASH FLOW	-264201	2647	-8121	31723	301	20224	561	90353	62282	56585

DISCOUNT RATE	PRESENT VALUE "A"	PRESENT VALUE "B"	TOTAL PRESENT VALUE
0.10	-120159	198328	78170
0.15	-144609	81084	-63524
0.20	-158457	38079	-120379
0.25	-165719	19443	-146277
0.30	-168840	10525	-158316

PRESENT VALUE OF "A" IS THE PRESENT VALUE OF THE CASH FLOWS, YEAR 1 THROUGH 10
PRESENT VALUE OF "B" IS THE PRESENT VALUE OF THE CASH FLOWS, YEAR 11 AND AFTER

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
DEBT TO CAPITALIZATION RATIO	0.58	0.72	0.83	1.17	1.27	1.49	1.76	4.30	2.23	2.12
RETURN ON ASSETS	0.06	0.07	0.08	0.09	0.09	0.10	0.11	0.14	0.11	0.11
RETURN ON CAPITALIZATION	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17

FINANCIAL EXHIBIT 6.3.4 PRIVATE OWNERSHIP AND OPERATION

ORIGINAL PAGE IS OF POOR QUALITY

Econ

SCENARIO # 3
PRIVATE OWNERSHIP AND OPERATION

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED U.S. GOVERMENT CASH FLOWS
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT
YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
U.S. GOVERMENT EXPENDITURES:										
INFORMATION PRODUCTS	10190	13130	14250	14120	14300	14340	17850	20980	24310	27340
ASSET PURCHASES	0	0	0	0	0	0	0	0	0	0
OPERATIONS COSTS(NET OF RE-IMBURSEMENTS	0	0	0	0	0	0	0	0	0	0
R&D COSTS	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
EQUITY CONTRIBUTION	0	0	0	0	0	0	0	0	0	0
SUBSIDY	160000	142500	180000	125000	120000	155000	180000	215000	175000	155000
TOTAL US GOV'T EXPENDITURES	180190	165630	204250	149120	144300	179340	207850	245980	209310	192340
U.S. GOVERNMENT RECEIPTS:										
RECEIPTS FROM LEASE(GRD FAC)	26100	26100	26100	26100	0	0	0	0	0	0
NON-GOVERMENT DATA SALES AND GROUND STATION FEES	0	0	0	0	0	0	0	0	0	0
ASSET RECOUPMENT	279700	0	0	0	0	0	0	0	0	0
TDRSS USEAGE FEES	5235	7134	7728	7216	6935	5655	7470	9284	10552	11686
ROYALTY FEES	0	0	0	0	0	0	0	0	0	0
TAX REVENUE	0	0	0	0	0	0	22942	41198	31754	34111
DIVIDENDS RECEIVED	0	0	0	0	0	0	0	0	0	0
TOTAL US GOV'T RECEIPTS	311035	33234	33828	33318	6935	5655	30412	50482	42306	45798
NET US GOV'T EXPENDITURES	-130855	132396	170422	115802	137365	173685	177438	187498	167005	146543

DISCOUNT RATE	PRESENT VALUE "A"	PRESENT VALUE "B"	TOTAL PRESENT VALUE
0.10	686777	513623	1200399
0.15	519669	209999	729658
0.20	399897	98514	498511
0.25	312099	50352	362451
0.30	246421	27256	273677

PRESENT VALUE OF "A" IS THE PRESENT VALUE OF THE CASH FLOWS, YEAR 1 THROUGH 10
PRESENT VALUE OF "B" IS THE PRESENT VALUE OF THE CASH FLOWS, YEAR 11 AND AFTER

FINANCIAL EXHIBIT 6.3.5 PRIVATE OWNERSHIP AND OPERATION

PHASED PRIVATE OWNERSHIP (6)
(PRIVATE SECTOR MARKETING)

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985 1994
FINANCIAL PROJECTIONS
PROJECTED STATEMENT OF INCOME
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
REVENUE										
DATA FEDERAL	10180	13130	14250	14120	14300	14340	17850	20980	24310	27340
-NON-FEDERAL	7790	9760	11260	12830	12960	10970	15190	17570	17750	19170
FOREIGN STATION FEES	8736	9968	11325	12000	12720	13485	14295	15150	16065	17025
OTHER REVENUE	0	0	0	0	0	0	0	0	0	0
ADDITIONAL FEDERAL PURCHASE	0	0	0	0	0	0	0	0	0	0
TOTAL REVENUE	26706	32858	36835	38950	39980	38795	47335	53700	58125	63535
DIRECT COSTS:										
PROCESSING	0 (37)	0	0	0	0	0	0	0	0	0
ARCHIVAL	0 (37)	0	0	0	0	0	0	0	0	0
SALES	0 (37)	0	0	0	0	0	0	0	0	0
ROYALTIES	33500	33500	33500	33500	33500	33500	37868	42960	46500	50828
TOTAL DIRECT COSTS	33500	33500	33500	33500	33500	33500	37868	42960	46500	50828
GROSS MARGIN	-6794	-642	3335	5450	6480	5295	9467	10740	11625	12707
OTHER OPERATING COSTS:										
INDIRECT COSTS	0	0	0	0	0	0	0	0	0	0
RESEARCH & DEVELOPMENT	0	0	0	0	0	0	0	0	0	0
ADVERTISING & PROMOTION	1425	1643	1842	1948	1999	1940	2367	2685	2906	3177
COMMUNICATIONS COST:										
-TDRSS	0(38)	0	0	0	0	0	0	0	0	0
-DOMSAT	0(38)	0	0	0	0	0	0	0	0	0
LEASE COSTS-GROUND SEGMENT	0	0	0	0	0	0	0	0	0	0
SPACE SEGMENT	0	0	0	0	0	0	0	0	0	0
DEPRECIATION-GROUND SEGMENT	0	0	0	0	0	0	0	0	0	0
-SPACE SEGMENT	0	0	0	0	0	0	0	0	0	0
INTEREST	369	385	612	619	492	291	110	0	0	0
OTHER EXPENSES	0	0	0	0	0	0	0	0	0	0
TOTAL INDIRECT EXPENSES	1794	2028	2454	2566	2491	2231	2477	2685	2906	3177
BEFORE TAX PROFIT-OPERATIONS	-8588	-2670	881	2884	3989	3064	6990	8055	8719	9530
INTEREST INCOME	0	0	0	0	0	0	0	0	0	0
BEFORE TAX PROFIT-OPERATIONS	-8588	-2670	881	2884	3989	3064	6990	8055	8719	9530
PROVISION FOR FEDERAL TAXES	4380	1362	-449	-1471	-2034	-1563	-3565	-4108	-4447	-4860
INVESTMENT TAX CREDIT	0	0	0	0	0	0	0	0	0	0
R&D TAX CREDIT	0	0	0	0	0	0	0	0	0	0
NET INCOME	-4208	-1308	432	1413	1955	1501	3425	3947	4272	4670

FINANCIAL EXHIBIT 6.4.1 PHASED PRIVATE OWNERSHIP (PRIVATE SECTOR MARKETING)

ORIGINAL PAGE IS OF POOR QUALITY

PHASED PRIVATE OWNERSHIP
(PRIVATE SECTOR MARKETING)

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED BALANCE SHEETS
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT
YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
ASSETS										
FIXED ASSETS:										
GROUND SEGMENT	0	0	0	0	0	0	0	0	0	0
SPACE SEGMENT	0	0	0	0	0	0	0	0	0	0
TOTAL FIXED ASSETS	0	0	0	0	0	0	0	0	0	0
LESS:ACCUMULATED DEPRECIATION	0	0	0	0	0	0	0	0	0	0
NET FIXED ASSETS	0	0	0	0	0	0	0	0	0	0
CURRENT ASSETS	5488	6752	7569	8003	8215	7972	9726	11034	11943	13655
OTHER CURRENT ASSETS	0	0	0	0	0	0	0	0	0	0
TOTAL ASSETS	5488	6752	7569	8003	8215	7972	9726	11034	11943	13655
CAPITALIZATION AND LIABILITIES										
CAPITALIZATION:										
CONTRIBUTED CAPITAL	4000	4000	4000	4000	4000	4000	4000	4000	4000	4000
RETAINED EARNINGS	-4208	-5516	-5085	-3672	-1717	-216	3216	7157	11429	16699
CUMULATIVE DIVIDENDS PAID	0	0	0	0	0	0	-1374	-4576	-8263	-12766
TOTAL CAPITALIZATION	-208	-1516	-1085	328	2283	3784	5836	[illegible]	7166	7933
LONG-TERM DEBT	3500	5567	5626	4474	2646	998	0	0	0	0
CURRENT LIABILITIES	2195	2701	3028	3201	3286	3189	3891	4414	4777	5722
TOTAL LIABILITIES	5695	8268	8653	7675	5932	4187	3891	4414	4777	5722
TOTAL LIAB AND CAPITALIZATION	5488	6752	7569	8003	8215	7972	9726	11034	11943	13655

FINANCIAL EXHIBIT 6.4.2 PHASED PRIVATE OWNERSHIP (PRIVATE SECTOR MARKETING)

PHASED PRIVATE OWNERSHIP
(PRIVATE SECTOR MARKETING)

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED STATEMENT OF CHANGES
IN FINANCIAL POSITION
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT
YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
USES OF WORKING CAPITAL:										
NET LOSS	4208	1308	0	0	0	0	0	0	0	0
ITEMS WHICH DO NOT PROVIDE (USE) WORKING CAPITAL:										
DEPRECIATION AND AMORT	0	0	0	0	0	0	0	0	0	0
WORKING CAP APPLIED TO OPER	4208	1308	0	0	0	0	0	0	0	0
PAYMENT OF DIVIDENDS	0	0	0	0	0	0	0	0	0	0
ADDITIONS TO EQUIPMENT	0	0	0	0	0	0	1374	3162	3727	4003
REDUCTION IN L.T. DEBT	0	0	0	1152	1828	1648	998	0	0	0
INCREASE IN WORKING CAPITAL	3293	758	490	261	127	0	1053	785	546	667
	7500	2067	490	1413	1955	1649	3425	3947	4272	4670
SOURCES OF WORKING CAPITAL:										
NET INCOME	0	0	432	1413	1955	1501	3425	3947	4272	4670
PROCEEDS FROM SALE OF C/S	4000									
PROCEEDS FROM L.T. DEBT	3500	2067	59	0	0	0	0	0	0	0
DECREASE IN WORKING CAPITAL	0	0	0	0	0	146	0	0	0	0
	7500	2067	490	1413	1955	1648	3425	3947	4272	4670
CHANGES TO WORKING CAPITAL:										
INCREASE(DECREASE) TO CURRENT ASSETS	5488	1264	817	435	212	-243	1755	1308	909	1112
INCREASE(DECREASE) TO CURRENT LIABILITIES	2195	506	327	174	85	-97	702	523	364	445
INCREASE(DECREASE) IN WORKING CAPITAL	3293	758	490	261	127	-146	1053	785	546	667

FINANCIAL EXHIBIT 6.4.3 PHASED PRIVATE OWNERSHIP (PRIVATE SECTOR MARKETING)

ORIGINAL PAGE IS
OF POOR QUALITY

PHASED PRIVATE OWNERSHIP
(PRIVATE SECTOR MARKETING)

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED CASH FLOW
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
APPLICATIONS OF CASH:										
NET LOSS	-4208	-1308	0	0	0	0	0	0	0	0
ITEMS WHICH DO NOT PROVIDE CASH:										
DEPRECIATION	0	0	0	0	0	0	0	0	0	0
ADDITIONS TO FIXED ASSETS	0	0	0	0	0	0	0	0	0	0
INCREASE IN ACCOUNTS REC	-4390	-1011	-654	-748	-169	195	-1404	-1045	-727	-889
TAX ADJUSTMENT	-4380	-1362	449	.471	2034	1553	0	0	0	0
TOTAL APPLICATIONS OF CASH	-12978	-3681	-205	1123	1865	1758	-1404	-1046	-727	-889
SOURCES OF CASH:										
NET INCOME	0	0	432	1413	1955	1501	3425	3947	4272	4670
INCREASE IN CURRENT LIAB.	2195	506	327	174	85	-97	702	523	364	445
TAX ADJUSTMENT	0	0	0	0	0	0	0	0	0	0
TOTAL SOURCES OF CASH	2195	506	759	1587	2039	1404	4127	4470	4636	5114
CASH FLOW	-10783	-3176	554	2710	3964	3162	2723	3424	3908	4225

DISCOUNT RATE	PRESENT VALUE "A"	PRESENT VALUE "B"	TOTAL PRESENT VALUE
0.10	331	14807	15139
0.15	-2257	6054	3797
0.20	-3939	2843	-1096
0.25	-5033	1452	-3581
0.30	-5737	786	-4951

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
DEBT TO CAPITALIZATION RATIO	-0.04	-0.18	-0.13	0.04	0.38	0.90	1.50	1.50	1.50	1.50
RETURN ON ASSETS	-0.77	-0.19	0.06	0.18	0.24	0.19	0.35	0.36	0.36	0.36
RETURN ON CAPITALIZATION			-0.40	4.30	0.86	0.79	0.59	0.60	0.60	0.60

FINANCIAL EXHIBIT 6.4.4 PHASED PRIVATE OWNERSHIP (PRIVATE SECTOR MARKETING)

SCENARIO # 4
PHASED PRIVATE OWNERSHIP
(PRIVATE SECTOR MARKETING)

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED U.S. GOVERMENT CASH FLOWS
###

	FISCAL YEARS									
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
U.S. GOVERMENT EXPENDITURES:										
INFORMATION PRODUCTS	10180	13130	14250	14120	14300	14340	17850	20980	24310	27340
ASSET PURCHASES	77920	94650	141830	57930	87640	100350	125020	44000	66000	44000
OPERATIONS COSTS(NET OF RE-IMBURSEMENTS	25461	27424	27601	26356	25144	23026	25975	29191	31541	33513
R&D COSTS	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
EQUITY CONTRIBUTION	0	0	0	0	0	0	0	0	0	0
SUBSIDY	0	0	0	0	0	0	0	0	0	0
TOTAL US GOV'T EXPENDITURES	123561	145204	193681	108406	137084	147716	178845	104171	131851	114853
U.S. GOVERNMENT RECEIPTS:										
RECEIPTS FROM LEASE(GRD FAC)	0	0	0	0	0	0	0	0	0	0
NON-GOVERMENT DATA SALES AND GROUND STATION FEES	0	0	0	0	0	0	0	0	0	0
ASSET RECOUPMENT	0	0	0	0	0	0	0	0	0	0
TDRSS USEAGE FEES	0	0	0	0	0	0	0	0	0	0
ROYALTY FEES	33500	33500	33500	33500	33500	33500	37868	42960	46500	50828
TAX REVENUE	0	0	0	0	0	0	3565	4108	4447	4860
DIVIDENDS RECEIVED	0	0	0	0	0	0	0	0	0	0
TOTAL US GOV'T RECEIPTS	33500	33500	33500	33500	33500	33500	41433	47068	50947	55688
NET US GOV'T EXPENDITURES	90061	111704	160181	74906	103584	114216	137412	57103	80904	59165

0.10	628763	207369	836132
0.15	519753	84781	604534
0.20	438187	39814	478002
0.25	375726	20329	396055
0.30	326891	11004	337896

FINANCIAL EXHIBIT 6.4.5 PHASED PRIVATE OWNERSHIP (PRIVATE SECTOR MARKETING)

ORIGINAL PAGE IS OF POOR QUALITY

LEGISLATIVELY CHARTERED, PRIVATELY OWNED CORPORATION

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED STATEMENT OF INCOME
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
REVENUE										
DATA-FEDERAL	16180	13130	14250	14120	14300	14340	17850	20980	24310	27340
-NON-FEDERAL	7790	9760	11260	12870	12960	10970	15190	17570	17750	19170
FOREIGN STATION FEES	8736	9968	11325	[illegible]	12720	13485	14295	15150	16065	17025
OTHER REVENUE	0	0	0	0	0	0	0	0	0	0
ADDITIONAL FEDERAL PURCHASE	169000	142500	180000	125000	120000	155000	180000	215000	175000	155000
TOTAL REVENUE	186706	175358	216835	163950	159980	193795	227335	268700	233125	218535
DIRECT COSTS:										
PROCESSING	12487(37)	12571	13450	12326	11520	9972	11520	13299	14545	15487
ARCHIVAL	2595(37)	2915	2914	2649	2469	2088	2484	2918	3216	3434
SALES	5614(37)	5238	5210	5020	4733	4189	4757	5300	5633	5951
ROYALTIES	0	0	0	0	0	0	0	0	0	0
TOTAL DIRECT COSTS	20693	21724	21573	19995	18722	16249	18761	21517	23393	24866
GROSS MARGIN	166613	153634	195262	143955	141258	177546	208574	247183	209732	193669
OTHER OPERATING COSTS:										
INDIRECT COSTS	5009	5310	5628	5966	6324	6703	7105	7532	7984	8463
RESEARCH & DEVELOPMENT	1068	1314	1473	1558	1599	1552	1893	2148	2325	2541
ADVERTISING & PROMOTION	1425	1643	1842	1948	1999	1940	2367	2685	2906	3177
COMMUNICATIONS COST:										
-TDRSS	5235(38)	7134	7728	7218	6935	5655	7470	9284	10552	11606
-DOMSAT	759(38)	391	399	395	98	73	148	142	164	184
LEASE COSTS-GROUND SEGMENT	26100	26100	26100	26100	23120	23120	23120	23120	23120	23120
SPACE SEGMENT	0	0	0	0	0	0	0	0	0	0
DEPRECIATION-GROUND SEGMENT	0	0	0	0	0	0	0	0	0	0
-SPACE SEGMENT	150233	78533	119383	40850	40850	64878	81225	81225	81225	57278
INTEREST	16653	15378	14973	15465	13567	15149	15231	15321	5569	11000
OTHER EXPENSES	0	0	0	0	0	0	0	0	0	0
TOTAL INDIRECT EXPENSES	208082	135804	177527	99499	94493	119030	138526	141456	133845	117408
BEFORE TAX PROFIT-OPERATIONS	-41469	17831	17735	44456	46765	58516	70055	105727	75887	76260
INTEREST INCOME	0	0	0	0	0	0	0	0	0	0
BEFORE TAX PROFIT-OPERATIONS	-41469	17831	17735	44456	46765	58516	70055	105727	75887	76260
PROVISION FOR FEDERAL TAXES	21149	-9094	-9045	-22673	-23850	-19843	-35728	-57921	-38702	-38893
INVESTMENT TAX CREDIT	35762	9465	14183	5793	8764	10035	12502	4400	6500	4400
R&D TAX CREDIT	160	197	221	234	240	233	284	322	349	381
NET INCOME	15603	18399	23694	27610	31919	38941	47113	56528	44133	42149

FINANCIAL EXHIBIT 6.5.1 LEGISLATIVELY-CHARTERED, PRIVATELY-OWNED CORPORATION

U053

LEGISLATIVELY CHARTERED, PRIVATELY OWNED CORPORATION

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED BALANCE SHEETS
###

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
ASSETS										
FIXED ASSETS:										
GROUND SEGMENT	0	0	0	0	0	0	0	0	0	0
SPACE SEGMENT	357620	452270	594100	652030	739670	840020	965040	1009040	1075040	1119040
TOTAL FIXED ASSETS	357620	452270	594100	652030	739670	840020	965040	1009040	1075040	1119040
LESS: ACCUMULATED DEPRECIATION	150233	228767	348150	389000	429850	494687	575912	657137	738362	795600
NET FIXED ASSETS	207387	223503	245950	263030	309820	345333	389128	351903	336678	323440
CURRENT ASSETS	38364	36032	44555	33688	32873	39821	46713	55212	47902	44904
OTHER CURRENT ASSETS	0	0	0	0	0	0	0	0	0	0
TOTAL ASSETS	245751	259536	290505	296718	342693	385153	435840	407115	384580	368344
CAPITALIZATION AND LIABILITIES										
CAPITALIZATION:										
CONTRIBUTED CAPITAL	75000	75000	75000	75000	75000	75000	75000	75000	75000	75000
RETAINED EARNINGS	15603	34002	57096	84906	116825	155765	202878	259406	303539	345688
CUMULATIVE DIVIDENDS PAID	0	0	0	0	0	0	0	0	-113120	-170305
TOTAL CAPITALIZATION	90603	109002	132095	159906	191825	230765	277878	334406	265419	250383
LONG-TERM DEBT	139803	136121	140587	123337	137719	138460	139277	50624	100000	100000
CURRENT LIABILITIES	15346	14413	17822	13475	13149	15928	18685	22085	19161	17962
TOTAL LIABILITIES	155148	150534	158409	136813	150868	154388	157962	72709	119161	117962
TOTAL LIAB AND CAPITALIZATION	245751	259536	290505	296718	342693	385153	435840	407115	384580	368344

FINANCIAL EXHIBIT 6.5.2 LEGISLATIVELY-CHARTERED, PRIVATELY-OWNED CORPORATION

ORIGINAL PAGE IS OF POOR QUALITY

U053

LEGISLATIVELY CHARTERED, PRIVATELY OWNED CORPORATION

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED STATEMENT OF CHANGES
IN FINANCIAL POSITION
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

FISCAL YEARS	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
USES OF WORKING CAPITAL:										
NET LOSS	0	0	0	0	0	0	0	0	0	0
ITEMS WHICH DO NOT PROVIDE (USE) WORKING CAPITAL:										
DEPRECIATION AND AMORT	-150233	-78533	-119383	-40850	-40850	-64839	-81225	-81225	-81225	-57238
WORKING CAP APPLIED TO OPER	-150233	-78533	-119383	-40850	-40850	-64838	-81225	-81225	-81225	-57238
PAYMENT OF DIVIDENDS	0	0	0	0	0	0	0	0	113120	57185
ADDITIONS TO EQUIPMENT	357620	[illegible]	141830	57930	87640	100350	125020	44000	66000	44000
REDUCTION IN L.T. DEBT	0	3682	0	17250	0	0	0	88653	0	0
INCREASE IN WORKING CAPITAL	23019	0	5114	0	0	4169	4135	5100	0	0
	230405	19798	27560	34330	46790	39681	47930	56526	97895	43947
SOURCES OF WORKING CAPITAL:										
NET INCOME	15603	18379	23094	27810	31919	38941	47113	56528	44133	42149
PROCEEDS FROM SALE OF C/S	75000									
PROCEEDS FROM L.T. DEBT	139803	0	4466	0	14382	741	817	0	49376	0
DECREASE IN WORKING CAPITAL	0	1399	0	6520	489	0	0	0	4386	1799
	230405	19798	27560	34330	46790	39681	47930	56528	97895	43947
CHANGES TO WORKING CAPITAL:										
INCREASE(DECREASE) TO CURRENT ASSETS	38364	-2332	8523	-10867	-816	6948	6892	8500	-7310	-2998
INCREASE(DECREASE) TO CURRENT LIABILITIES	15346	-933	3409	-4347	-326	2779	2757	3400	-2924	-1199
INCREASE(DECREASE) IN WORKING CAPITAL	23019	-1399	5114	-6520	-489	4169	4135	5100	-4386	-1799

FINANCIAL EXHIBIT 6.5.3 LEGISLATIVELY-CHARTERED, PRIVATELY-OWNED CORPORATION

LEGISLATIVELY CHARTERED PRIVATELY OWNED CORPORATION (DIVIDEND DISTRIBUTIONS NOT INCLUDED)										

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED CASH FLOW
***

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS									
	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
APPLICATIONS OF CASH:										
NET LOSS	0	0	0	0	0	0	0	0	0	0
ITEMS WHICH DO NOT PROVIDE CASH:										
DEPRECIATION	150233	78533	119383	40850	40850	64838	81225	81225	81225	57238
ADDITIONS TO FIXED ASSETS	-357620	-94650	-141830	-57930	-87640	-100350	-125020	-44000	-66000	-44000
INCREASE IN ACCOUNTS REC	-30691	1865	-6818	8693	653	-5559	-5513	-6800	5846	2398
TAX ADJUSTMENT	-57071	-569	-5359	16646	14846	19575	22942	49198	31754	34111
TOTAL APPLICATIONS OF CASH	-295149	-14820	-34624	5259	-31291	-21496	-28367	79624	52827	49747
SOURCES OF CASH:										
NET INCOME	15603	18399	23094	27810	31919	38941	47113	56528	44133	42149
INCREASE IN CURRENT LIAB.	15346	-933	3309	-4347	-326	2779	2757	3400	-2924	-1199
TAX ADJUSTMENT	0	0	0	0	0	0	-22942	-49198	-31754	-34111
TOTAL SOURCES OF CASH	30948	17466	26503	23463	31592	41720	26928	10730	9456	6838
CASH FLOW	-264201	2647	-8121	31723	301	20224	561	90353	62282	56585

DISCOUNT RATE	PRESENT VALUE "A"	PRESENT VALUE "B"	TOTAL PRESENT VALUE
0.10	-120159	198328	78170
0.15	-144609	81084	-63524
0.20	-158457	38079	-120379
0.25	-165719	19443	-146277
0.30	-168840	10525	-158316

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
DEBT TO CAPITALIZATION RATIO	0.58	0.72	0.83	1.17	1.27	1.49	1.76	4.60	2.23	2.12
RETURN ON ASSETS	0.06	0.07	0.08	0.09	0.09	0.10	0.11	0.14	0.11	0.11
RETURN ON CAPITALIZATION	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17

FINANCIAL EXHIBIT 6.5.4 LEGISLATIVELY-CHARTERED, PRIVATELY-OWNED CORPORATION

SCENARIO # 5
LEGISLATIVELY CHARTERED, PRIVATELY OWNED
CORPORATION

LAND REMOTE SENSING SYSTEM
FISCAL YEARS 1985-1994
FINANCIAL PROJECTIONS
PROJECTED U.S. GOVERMENT CASH FLOWS
###

AMOUNTS EXPRESSED IN THOUSANDS OF CURRENT
YEAR DOLLARS; 6% INFLATION RATE ASSUMED

	FISCAL YEARS 1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
U.S. GOVERMENT EXPENDITURES:										
INFORMATION PRODUCTS	10180	13130	14250	14120	14300	14340	17850	20980	24310	27340
ASSET PURCHASES	0	0	0	0	0	0	0	0	0	0
OPERATIONS COSTS(NET OF RE- IMBURSEMENTS	0	0	0	0	0	0	0	0	0	0
R&D COSTS	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
EQUITY CONTRIBUTION	24750	0	0	0	0	0	0	0	0	0
SUBSIDY	160000	142500	180000	125000	120000	155000	180000	215000	175000	155000
TOTAL US GOV'T EXPENDITURES	204930	165630	204250	149120	144300	179340	207850	245980	209310	192340
U.S. GOVERNMENT RECEIPTS:										
RECEIPTS FROM LEASE(GRD FAC)	26100	26100	26100	26100	0	0	0	0	0	0
NON-GOVERMENT DATA SALES AND GROUND STATION FEES	0	0	0	0	0	0	0	0	0	0
ASSET RECOUPMENT	279700	0	0	0	0	0	0	0	0	0
TDRSS USEAGE FEES	5235	7134	7728	7218	6935	5655	7470	9284	10552	11686
ROYALTY FEES	0	0	0	0	0	0	0	0	0	0
TAX REVENUE	0	0	0	0	0	0	22942	49198	31754	34111
DIVIDENDS RECEIVED	0	0	0	0	0	0	0	0	37330	18871
TOTAL US GOV'T RECEIPTS	311035	33234	33828	33318	6935	5655	30412	58482	79635	64669
NET US GOV'T EXPENDITURES	-106105	132396	170422	115802	137365	173685	177438	187498	129675	127672

DISCOUNT RATE	PRESENT VALUE "A"	PRESENT VALUE "B"	TOTAL PRESENT VALUE
0.10	686170	447481	1133650
0.15	525914	182947	709062
0.20	410240	85915	496155
0.25	324863	43858	368730
0.30	260570	23746	284317

PRESENT VALUE OF "A" IS THE PRESENT VALUE OF THE CASH FLOWS, YEAR 1 THROUGH 10
PRESENT VALUE OF "B" IS THE PRESENT VALUE OF THE CASH FLOWS, YEAR 11 AND AFTER

FINANCIAL EXHIBIT 6.5.5 LEGISLATIVELY-CHARTERED, PRIVATELY-OWNED CORPORATION

USGS

7. NONFINANCIAL ISSUES

A general overview is presented in the following paragraphs of the numerous nonfinancial issues related to the establishment of an operational land remote sensing system. These issues are not new having been discussed for at least the last half-decade. Many of the issues still being discussed were identified at the start of the ERTS/LANDSAT program over a decade ago; others that have been identified in recent years as more detailed proposals for a permanent operational framework have been put forward [2, 6, 8, 12, 13, 19, 37-46].

This section begins with an analysis of the philosophical and practical dimensions of the land remote sensing debate; it addresses the question "why has it been so difficult to develop a permanent framework for using this technology?" Issues are then discussed in terms of four broad categories: international and foreign policy, national security, legal/regulatory and institutional. Finally, there is a general summary of the policy requirements which must be met for success in creating an effective permanent framework for U.S. land remote sensing activities.

7.1 Commercialization of Land Remote Sensing: A Persistent Political Question

The experimental U.S. remote sensing program has been underway since the late 1960s, with the first satellite put in orbit over a decade ago; over $1.5 billion has been invested in the program to date. Over the past five years, there has been an extended and complex debate over how best to bring land remote sensing into operational status. Suggestions have included: creating an international consortium modeled on Intelsat to own and operate the system;* reconfiguring NASA as system operator;** creating a new private corporation for earth observations;*** and, after extensive review during the Carter Administration, assigning the management role to the National Oceanographic and Atmospheric Administration (NOAA) pending "eventual" transfer to private sector ownership and operation.**** Now, the current Administration has decided to terminate a direct

*This suggestion is contained in National Academy of Sciences, op. cit.

**This suggestion is contained in Augenstein, Shapley and Skolnikoff, op. cit., and a bill introduced in 1979 by Senator Adlai Stevenson (D-Ill.), S. 663, 96th Congress, 1st Session.

***This suggestion is contained in a bill introduced in 1979 by Senator Harrison Schmitt (R-N.M.), S. 875, 96th Congress, 1st Session.

****The Carter decision was announced in November 1979; it was contained in Presidential Directive 54.

government role in operating the system as soon as possible, with land observation satellites to be taken over by the private sector, either in combination with weather satellites or by themselves.* In stark contrast, in their responses to a Department of Commerce Request for Information in the fall of 1982, three major aerospace firms which have been intimately involved in earth observation programs suggested that the whole discussion of an operational system is premature, and that any move to commercialize land remote sensing at this time would undermine the long-term viability of the enterprise!

The point here is not to analyze these specific proposals in any detail, but rather to suggest why there have been so many widely different answers to a single question: "How to assure that U.S. society gets the maximum benefits from its investment in remote sensing research and development to date?" If it reveals nothing else, the history of the discussion so far tells us that there is no one "right" answer to that question.

Why is this so? There are both practical and philosophical reasons. They include:

- The LANDSAT demonstration program has not been a success, if success is defined as developing the information and experience required to make informed decisions with respect to the desirability of public vs. private ownership and the form of private ownership
- There is a mismatch between the capabilities provided by land observation technology and the structure of both public and private sector organizations which might benefit from those capabilities
- Land remote sensing can provide a wide variety of benefits ranging from intangible public goods to high dollar value private returns; there are strong differences in political philosophy and values over which of these benefits should be given priority in designing a permanent framework for operating the technology
- In a related way, there are persistent differences in perspective about the respective roles of government and the private sector in providing various services to society and about how best to insure return to the public from its investments in government research and development programs
- Finally, land remote sensing has inherently global dimensions, if only because it operates using resources which are recognized as global "commons"—outer space and the frequency spectrum. While it may be possible to design a framework for the technology on a national basis, there are inescapable international dimensions to the problem.

---

*Remote sensing policy under the Reagan Administration is reviewed in M. Mitchell Waldrop, "What Price Privatizing LANDSAT?" Science, February 11, 1983, pp. 752-754.

It is beyond the scope of this report to discuss any of these general concerns in depth, yet they provide the context within which the specific issues are discussed below. The recent discussions of commercialization, in particular, have been carried out against the backdrop of an expectation created early in the LANDSAT program that land remote sensing would create billions of dollars annually in benefits.* If indeed the technology, as soon as it was relatively mature, could have such an impact, and if the benefits could be provided as private goods, then clearly rapid commercialization was a plausible objective and potential operators should be struggling to be first in line to have an opportunity to profit from remote sensing.

That is clearly not the case. The market assessment presented in Section 4 indicates the limited size of the current market for LANDSAT products and suggests only moderate mid-term prospects for growth in products for which specific users would be willing to pay a significant price. There may well be extremely high benefits <u>to society</u> from employing land remote sensing technology, but it seems extremely difficult to provide those benefits in terms of private goods. The breakdown of potential benefits given in Table 7.1 may be useful in understanding the mixed public good/private good results of the use of this capability; that understanding is in turn a key to recognizing why it has been so difficult to reach agreement on most of the issues under debate.

In the end it is the political questions—the division of roles and responsibilities between the public and private sector—which is driving, and complicating, all of the discussions surrounding the permanent framework for land remote sensing. In many ways the current situation may be considered unique in that it involves a technology developed and demonstrated totally under public sector auspices and for which the federal government remains a major user, yet which has still been expected throughout its development to be eventually transferred to the private sector. Current patterns of operation, with users both inside and outside the government, run the risk of being disrupted by a possible transfer of the

*For example, in 1975 the value over a two-year period of information on wheat crops was estimated at $400 million to the United States and $1.7 billion to the rest of the world; benefits of a 1985 operational system (for information on wheat only) were estimated at $300 million/year for the United States and $1.5 billion/year for the rest of the world. American Institute of Aeronautics and Astronautics, <u>Space: A Resource for Earth</u> (New York, 1977), p. 28.

TABLE 7.1 U.S. INTERESTS IN CIVIL REMOTE SENSING

TECHNICAL INTERESTS

A. BASIC SCIENTIFIC KNOWLEDGE AND UNDERSTANDING OF VARIOUS FEATURES OF THE EARTH

B. GLOBAL CAPACITIES FOR DEALING WITH NATIONAL AND INTERNATIONAL PROBLEMS IN AGRICULTURE, ENERGY, ETC.

C. TECHNOLOGY DEVELOPMENT PROVIDING ADVANCEMENTS IN REMOTE SENSING AND RELATED FIELDS

PUBLIC INTERESTS

A. SPECIFIC FEDERAL NEEDS AND FUNCTIONS WITHIN VARIOUS AGENCIES AND PROGRAMMATIC AREAS

B. PUBLIC INTEREST NEEDS AND BENEFITS FOR STATES, LOCALITIES, UNIVERSITIES AND GENERAL PUBLIC

C. SUPPORT FOR U.S. DECISION MAKING BY PROVIDING INFORMATION ON SUCH ITEMS AS CROP PRODUCTION IN FOREIGN COUNTRIES

ECONOMIC INTEREST

A. ECONOMIC INTERESTS OF U.S. PRIVATE SECTOR IN A VARIETY OF FIELDS, I.E., OIL AND MINERAL EXPLORATION

B. U.S. COMPETITIVE POSITION IN SPACE TECHNOLOGY INCLUDING MANUFACTURING AND SERVICING OF EQUIPMENT, DISSEMINATION OF DATA, PROVISION OF TECHNICAL SERVICES AND ANALYSIS

C. REDUCTION IN INFORMATION COSTS FOR FEDERAL, STATE, LOCAL AND PRIVATE SOURCES

D. CONTRIBUTION TO GENERAL ECONOMIC GROWTH BOTH OF LDCs AND THE WORLD AS A WHOLE

E. RETURN ON SPACE INVESTMENT WITH ECONOMIC AND OTHER KINDS OF BENEFITS FOR NOMINAL COST

U.S. INTERNATIONAL INTERESTS

A. SUPPORT FOREIGN POLICY THROUGH PROVISION OF INFORMATION AND RELATED SERVICES

B. MAINTAIN U.S. LEADERSHIP WITH THIS TECHNOLOGY AS ILLUSTRATION OF CONTINUED LEADERSHIP IN SPACE

C. SUPPORT U.S. POSITION WITH LDCs HONORING COMMITMENTS FOR TECHNOLOGY AND BUTTRESSING POSITION IN NORTH/SOUTH DIALOGUES, THE U.N. AND OTHER FORUMS

D. SUPPORT INTERNATIONAL COOPERATION IN SPACE VIA COMMITMENTS TO FOREIGN GROUND STATIONS AND OTHER INVESTORS FOR DATA CONTINUITY AND EVENTUAL SYSTEMS COMPATIBILITY

E. PROMOTE OPENNESS THROUGH THE TREATMENT OF GENERAL INFORMATION AS AN INTERNATIONAL GOOD

F. GENERAL INTERNATIONAL COOPERATION AS MODEL OF EFFECTIVE WORKING RELATIONSHIPS AMONG NATIONS

SOURCE: EARTH INFORMATION FROM SPACE BY REMOTE SENSING, A REPORT PREPARED FOR OSTP BY BRUNO AUGENSTEIN, WILLIS SHAPLEY AND EUGENE B. SKOLNIKOFF, JUNE 2, 1978, PP. 4-7.

system. Thus both political interests and organizational inertia are involved in this transfer, making the decision even more difficult.

Successful commercialization depends on whether there are sufficient private benefits to lead to an eventual satisfactory return on investment for a private operator, recognizing the existence of a continuing and substantial government demand for land remote sensing services. As one of its findings, the Subcommittee on Space and Applications, of the House Committee on Science and Technology, concluded that

> The greatest negative influence on the evolution of an operational civil and land remote sensing system has been the inability to fully evaluate the relationship between LANDSAT and national needs to provide a long-range policy that is continuously reflected in the budget.*

All in all, given the economic factors discussed elsewhere in this report, the past history of the LANDSAT program and the current nonfinancial issues discussed in this section, the task of designing an appropriate long-term framework for the land remote sensing system is about as challenging as one could ever find. As mentioned earlier, it is obvious that the issues raised reflect fundamental differences in political philosophy which exist in the U.S. society; the dominant philosophy at a particular time determines priorities and defines the appropriate role of government. All of these differences are the topic of continuing political debates and are unresolvable analytically. Inevitably, an eventual decision on a permanent framework for the land remote sensing is going to be a political decision in which one set of values prevails over another. This report can make a contribution to informing those participating in such debate, but it cannot substitute for the political process.

7.2 International and Foreign Policy Issues

The capability to make useful observations of all parts of the earth's land surface from orbit, using a U.S.-developed and operated satellite system, has provided a foreign policy opportunity for the United States. It has also created international demands that the United States, along with other potential operators of earth observation systems, be governed by a series of existing and emerging international obligations and principles related to remote sensing. These opportunities and obligations define an essential part of the context within which

*House Committee on Science and Technology, Civil Land Remote Sensing, op. cit., p. 4.

various scenarios related to a permanent U.S. remote sensing venture must be evaluated.

Current U.S. government policy with respect to the international aspects of remote sensing dates back to Richard Nixon's 1969 pledge before the U.N. General Assembly that "this program will be dedicated to producing information not only for the U.S. but also for the world community." In the years since, the United States has put forth, and defended strongly against criticism, a policy of open and nondiscriminatory access on the part of all countries and their citizens to the products of the LANDSAT system. The United States has taken positive steps, ranging from allowing other countries direct access to LANDSAT spacecraft with their own ground stations to providing technical assistance to countries wishing to use LANDSAT information, to implement Nixon's 1969 statement and its open access policy. Any attempts to reverse the policy, to change the expectations or to modify the patterns of use which have evolved over the past decade will be certain to create international tension.

The current state of international thinking on remote sensing, at least on the governmental level, is perhaps best reflected in the report of the 1982 Unispace Conference. That report noted that although remote sensing is still in a "preoperational" stage, "it is only a matter of time—and a short time—before this very important application attains a completely operational status." Given this reality, the report said "agreement should be reached on principles governing satellite remote sensing. Work to this effect....should be continued as a matter of priority, aimed at speedy agreement on such principles." In addition to a framework of general principles, concern was expressed that

> Satellite operators should give assurance about continuity of data flows and provide indications about estimated lifetime [of] preoperational and operational systems in order to help all countires, in particular the developing countries. Compatability of various systems and data formats is another important aspect....
>
> Since remote sensing can collect data from all countries, it is therefore possible to use shared or internationally-owned remote sensing satellites....
>
> It is suggested that a study be undertaken to assess the need for and the viability of a worldwide remote sensing system. Such a study could consider various ways of providing remote sensing data—including regional, bilateral, multilateral and international arrangements—with the users bearing therefore the development, production, launching and operation costs of the satellites. Assuming that any one of these systems could provide assurance of continuity of data formats, avoid

forced obsolescence of equipment, and enable the development and use of standardized data analysis software, the study should in particular indicate the comparative cost of such systems to the users vis-a-vis systems currently in operation and/or under development.

A persistent issue in international discussions is "a possible situation in which data are not available to the sensed State but are available for commercial and other forms of exploitation by another country." At the conference

> Some delegations expressed serious concern regarding the dissemination of data collected by remote sensing satellites. While several developed and developing countries felt that such information should be freely available to any interested State, most delegations felt that the consent of the sensed State should be required before data could be released to a third State organization or third party. Some developing nations felt that the consent of the sensed State must be obtained before sensing, even if the information was not to be disseminated beyond the concerned States: some felt that in no case should the information be available to any State other than the sensor and sensed States. Most representatives expressing an opinion on the point agreed that priority in access to data must be accorded the sensed State.*

The central points made by potential foreign users** of land remote sensing products, then, are:

- The need for continuity in operation and overall system characteristics
- The need for guaranteed access at an acceptable price with provisions to avoid intrusions on national sovereignty.

The United States has attempted to deal with these pressures from the international community in ways that maximize these U.S. policy objectives:

- Maintaining U.S. leadership in space technology
- Assisting the economic and social development of the developing countries
- Promoting international cooperation as a means of achieving common objectives and as an example of the benefits of harmonious relationships among nations
- Ensuring U.S. ability to use space technology for its own national objectives, including operation of earth observation systems by both civil and national security agencies

---

*United Nations, Report of the Second United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, August 9-12, 1982, A/CONF.101/10.

**The current debate is between the United States, as the country farthest along in developing a remote sensing system, and countries without plans to develop their own systems. In general, other potential system operators, such as France and Japan, have moved to a position close to that of the United States on such issues as the need for prior consent of a sensed state.

- Enhancing the development of the U.S. economy by fostering new industries, new employment opportunities and new markets for U.S. firms.

In seeking to achieve these objectives the U.S. government has entered into a series of legal and political obligations. These include:

- The provisons of the Outer Space Treaty of 1967 which require "States party to the Treaty" to "bear international responsibility for national activities in outer space,...whether such activities are carried on by governmental agencies or by nongovernmental entities;" such nongovernmental activities "require authorization and continuing supervision by the appropriate State party to the Treaty."*
- A series of agreements negotiated with other governments to permit them access under mutually agreeable terms to the output of U.S. remote sensing satellites using foreign owned and operated ground stations.
- Through our advocacy of the policy of open, nondiscriminatory access in UN forums and otherwise, a fairly explicit obligation not to create either formal or informal (such as unaffordable prices or continuing changes in technical format of the system output) barriers to any country, organization or individual who wants to use the system, with all users receiving nondiscriminatory treatment.
- Through negotiations in the International Telecommunications Union, agreement not to use the frequencies allocated for communicating remote sensing data streams to ground stations for any other purpose.

Given this melange of concerns, objectives and obligations, a few of the international issues which are suggested include:**

Future International Negotiations

Over coming years as remote sensing capabilities evolve, there are sure to be continuing international negotiations. These will take place in the United Nations, other permanent multilateral organizations, ad hoc or informal multilateral groups, or on a bilateral basis. Participation in these negotiations may vary, depending on the framework adopted for U.S. remote sensing activities. If a private sector option is selected, what international role, if any, will the private sector operator want the U.S. government to play? What role will U.S. government agencies believe is required to protect U.S public interests?

*Treaty on Principles Covering the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 1967, Article VI.

**This discussion treats only the distinction between a government-owned system and a privately-owned system without attention to various scenarios for private ownership. Such treatment is provided in the comparative analysis in Table 8.2

Evolution of International Principles to Govern Remote Sensing

After ten years of debate in the U.N. Committee on Peaceful Uses of Outer Space (COPUOS), there remain major differences. Prospects for consensual agreement (which is the standard practice for this committee) are dim. In a similar situation with respect to direct broadcast satellites, a majority of countries agreed to move the issue from COPUOS to the Political Committee of the General Assembly, which operates according to majority vote. The United States opposed this move, and the principles which resulted from it. Might the prospect of transfer to private sector operation stimulate a similar attempt?

Maintenance of Open Nondiscriminatory Access

The interests of a commercial operator might sometimes conflict with the long-standing U.S. policy in this area; one way of increasing the value of remote sensing products is to limit their dissemination. Another is by providing priority access to some users. The Department of Commerce Land Remote Sensing Satellite Advisory Committee recommended that there be a government requirement "that the operator, whether it be the government and/or the private sector, subscribe to the open sky policy—which primarily means that anyone, anywhere, in any countries can purchase the data at equitable prices."* The current government policy, as enunciated in President Reagan's space policy statement of July 4, 1982, is to "support the public, nondiscriminatory direct readout of data from federal civil systems to foreign ground stations and the provision of data to foreign users under specified conditons."** The policy is silent on requirements for nonfederal systems.

One way to restrict access to remote sensing data is to adopt policies which are explicitly discriminatory. Another means is to price certain data (such as "quick looks") in ways that exclude some potentially interested users. This possibility has been noted by the international community, for example, a Romanian spokesman told COPUOS this spring of his concern about "the relatively new question of considering satellite remote sensing activities as operational, on a purely commercial basis, with the immediate consequence of augmenting by

*Department of Commerce, Minutes of the Land Remote Sensing Satellite Advisory Committee meeting, November 1982.

**The public statement of Administration space policy is contained in a White House Fact Sheet, "National Space Policy," July 4, 1982.

several times the cost of remote sensing products. Under these conditions, effective access to the data is practically possible only for developed countries."

How will considerations of cost recovery and even commercial profit interact with an open access policy as an operational system evolves? Will system products be provided to poorer countries on a subsidized basis? What are the interactions among U.S. policy objectives vis-a-vis developing countries, the economic viability of an operational system and the general concern of avoiding tensions? Although poorer countries may in the long term have the prospect of receiving the most benefits from remote sensing, who will make the investments required for them to be effective users, and thus a growing market for the system? In the short run, would more expensive products from a private commercial system drive away non-U.S. users?

Meaning of U.S. Leadership in Space Technology

Current policy is to "maintain United States space leadership," particularly in "critical aspects of space, applications and technology;" in these areas, the objectives is "preeminence."* The meaning of this policy with respect to remote sensing technology is unclear. Given the emerging foreign competition in the field, how will the U.S. government respond: by a continued program of R&D in the remote sensing area, keyed to staying ahead of competing systems; by reliance on the private sector to develop a superior system for the United States, without continuing government R&D subsidies; by providing subsidies or incentives beyond R&D to a commercial operator in order to help it best foreign competition and thus bring the benefits of a growing remote sensing industry (sales of equipment; training of non-U.S. personnel; consulting services, etc.) to the U.S. economy? Or is civil remote sensing not a "critical" area, and thus not one which requires U.S. leadership? What would be the costs, in terms of mo[illegible] ge[illegible]al foreign policy or economic objectives, of a non-U.S. system dominating the world market for remote sensing? This could happen if no commercial system is established and the U.S. government withdraws from remote s[illegible] activity after LANDSAT D' reaches the end of its lifetime, or if the U.S. co[illegible]cial venture is unsuccessful.

---

*The public statement of Administration space policy is contained in a White House Fact Sheet, "National Space Policy," July 4, 1982.

Econ

Future of Non-U.S. Ground Stations

It is likely that any future U.S. remote sensing system will use a data relay satellite to return data to U.S. ground station. Thus there will be no strong requirement, from a U.S. perspective, for direct readouts to ground stations outside the United States. For a number of years, the U.S. government has permitted, even encouraged, the development of such ground stations, mainly as means of underlining U.S. policy on open access and as a symbol of friendly relationships. Other governments have entered into agreements with the United States government with respect to access to LANDSAT and have made substantial investments in ground stations and related data processing and interpretation equipment. The motivations of these countries have ranged from national prestige to a careful calculation of tangible payoffs from the use of LANDSAT data.

The role of foreign ground stations in an era of operational remote sensing systems is problematical. If cost recovery is the objective of a government system, will the access fee and royalty arrangements have to increase to levels which foreign operators will find hard to accept? Will the U.S. government provide what is in effect subsidized access to foreign operators? If a private U.S. system evolves, what changes will result in the relationship with non-U.S. entities, which negotiated their current arrangements with the U.S. government? Would some countries prefer to deal with a non-U.S. system rather than a U.S. system which is privately operated? Could non-U.S. ground stations be effective in the role of regional franchised distributors of remote sensing products, operating in a commerical context? How could any proprietary restrictions on remote sensing data, e.g., copyright, be policed and enforced when there is multiple access to the system?

Creating Dependency Relations

To date few entities (including those in the United States) are critically dependent on the availability of remote sensing data to achieve their important objectives. As the technology matures and its use becomes widespread, this situation could change. This has positive aspects from a U.S. perspective, since it would place the country in a position to exert some influence on global developments because it controlled a technological resource with global implications. There are negative aspects as well; for example, countries which depend on reliable access to U.S.-supplied remote sensing data may protest or retaliate if, for some overriding reason, the U.S. system should go out of service, charge excessively high

Econ

prices, or provide products with degraded quality. By making remote sensing a critical tool in the common task of managing the global ecosystem, the United States takes the responsibility of long-term, high-quality performance of its earth observation systems.

This discussion of the international aspects of land remote sensing has been extensive because the international character of the system presents extremely difficult issues to those attempting to select a framework for the U.S. operational system. This is especially the case when the general foreign policy issues discussed in this section are examined together with those issues more closely related to national security concerns. The next section is such an examination.

7.3 National Security Issues

It is a matter of public record that the United States uses earth observation satellites as one of its means of gathering intelligence information with respect to other areas of the world; these satellites are assets of extremely high value to U.S national security interests. The capabilities of these satellites have also been extensively discussed,* and in most parameters they clearly exceed those available for civilian use. However, it is also reasonable to suggest that some information with intelligence significance can be extracted from existing civilian land observation satellites and that existing national security systems may not duplicate all capabilities available in civilian satellites (for example, coverage in particular spectral bands). Thus there are unavoidable national security aspects to the routine operation of a civilian land remote sensing system. In times of international tensions or crises, these aspects become more pronounced, and the U.S. government will want to ensure that its national security agencies will be able to control all earth observation systems in that situation.

Just as earth observation systems have both civilian and national security applications, the technologies on which they are based have "dual use" characteristics. Capabilities developed initially for national security purposes have potential relevance to civilian uses, and the technologies involved in sensors, data processing, image interpretation, etc. are sensitive in terms of export control regulations.

---

*For a discussion of the capabilities of various U.S. observation satellites, see Thomas H. Karas, The New High Ground, New York: Simon & Schuster, 1983, Ch. 4.

Given these realities, the following national security issues are suggested.

"Open Skies" Precedent and Ability to Carry Out National Security Observations

One not quite incidental fallout from the U.S. policy of open, nondiscriminatory access to the products of government earth observation systems operated for civilian purposes is the creation of a climate in which all U.S. observation satellites can function without drawing protests from the countries of the world. Any modification of an open access policy, particularly by a private operator seeking competitive advantage or increased economic return, could change this situation. For example, in the wake of the recent Administration announcement of its intent to transfer ownership and operation of civilian earth observation satellites to the private sector, one Canadian official indicated that his government was "very concerned," saying "we have a satellite looking down at our country and we don't call it a spy satellite because we have nondiscriminatory access to it. ...But if we were charged 100 times as much by some company, then we might have to begin to wonder about this."*

Tradeoffs Between National Security Interest and Economic Competiveness Concerns

Under continued government ownership and operation of the land remote sensing satellite system, past patterns of coordination between national security agencies and civilian agencies such as NASA and NOAA would likely persist. Some civilian sector objectives differ from those of the intelligence community, which has taken a conservative position on making available advanced sensor capabilities. On the whole, however, the relationship between the two sectors of the government has worked well. The potential for the transfer of the system out of government control does create serious questions regarding the extent of government supervision necessary and possible. National security-related areas in which a possible regulatory regime might engage itself include: spectral resolution, center frequency and tunable range; spatial resolution; geographic coverage; timeliness of data availability; tasking procedures and controls; and data dissemination policies.

The kind of quiet coordination which is possible within the government would be much more difficult to maintain in a relationship with a private sector entity.

---

*Washington Post, March 8, 1983, p. 1.

In the instance of private sector operation of the system, it becomes very important to recognize the need to temper national security considerations when designing an appropriate regulatory regime. Due regard must be given to the international market in which the private entity is operating, so that regulatory practices do not seriously erode the system's competitive position. A private operator may find, for example, that improved sensor characteristics may be required in order to keep itself economically solvent.

From the national security point of view, those sensor characteristics may present problems either in terms of revealing sensitive U.S. technological capabilities or in terms of providing images of the United States or other countries from which intelligence information could be extracted. If sensor capabilities were to be improved, then the intelligence community might want to involve itself in the process of determining appropriateness of data for dissemination.

Reaching a balance between considerations of national security on one hand, and the need to develop a high performance, economically competitive system, on the other, will continue to be a very difficult and complicated issue as land remote sensing satellite technology develops. Further aggrevating this balance is the fact that U.S. national security interests and controls are in a large part derived from a different set of motivations and values than the potential security controls which might be applied to the French, European or Japanese systems. Thus there is unlikely to be easy agreement among operators of remote sensing systems over what are acceptable limits on system performance from a national security perspective.

Export Control Regulations and Land Remote Sensing

There is heightened concern in recent years that U.S.-developed technology is being acquired by our adversaries and used as a major basis for their military capabilities.* There is also recognition that the export of products and services based on advanced technology is a major source of positive U.S. balance-of-trade. Creating an operational U.S. land observation system aimed at dominating the international market brings with it an export control issue: will the United States aggressively seek to supply all elements required for other countries to participate in such a system, e.g., ground stations, computing capability, image interpretation

*This argument is made in, for example, Department of Defense, Soviet Military Power, 1983.

capability, or will concerns over the export of sensitive or dual-use technologies limit the ability of the United States to capitalize fully on such a marketing opportunity?

National security concerns such as those embodied in the last two issues discussed above, in the context of a privately-operated system, must be addressed within the framework of whatever regulatory regime is created to oversee such a system. Such legal and regulatory issues are discussed in the following section.

7.4 Regulatory and Legal Issues

Most regulatory issues arise, almost by definition, in the case of private sector operation of a land remote sensing system. Since any private system a) carries with it the international and national security implications discussed above, b) will be based on publicly-funded research and demonstration results, and c) will be serving a large variety of government needs, it is appropriate that the government take the measures required to protect the public interest with respect to private system operation.

Conversely, a private system operator has the right to protection of its commercial interests; it should not be required to operate under conditions which prevent or inhibit success in developing a private sector remote sensing industry, and it may require various forms of government protection or assistance to develop such an industry.

Whatever kind of legal and regulatory framework is adopted at the initiation of a private sector land remote sensing venture, it must be flexible enough to evolve over time as the enterprise grows and adapts to a changing operational and competitive situation. There will also have to be a decision on how general/specific any regulatory framework should be. Most potential private sector operators would probably prefer the most general kind of regulations which are politically acceptable; given the many facets of system operation which are candidates for regulation, however, public authorities may decide that a relatively specific set of regulatory requirements will best protect the public interest.

One area of common concern, whether the system is governmentally- or privately-operated, is that of proprietary controls over data and system products. If any kind of cost recovery is a system goal, then it appears that some form of control, such as copyright, is required to prevent secondary duplication and dissemination of system products.

The issues discussed below, then, reflect a decision to transfer land remote sensing responsibility to some form of private operator.

Protection Against Competition?

The key issue here is whether the land remote sensing enterprise is a natural monopoly, and thus deserving of government protection from damaging competition, or whether over the next few years various potential private suppliers of remote sensing services will emerge. In this latter case, the appropriate role for government is to preserve a competitive environment and to prevent undesirable monopoly control. The findings of this report suggest that, at least for each class of remote sensing products individually, only one commercial venture can be successful, and thus that the situation does indeed resemble that of a natural monopoly. It is a slightly different question, however, whether that monopoly organization should be allowed to evolve through proving itself superior to any competition over a period of time, or whether it should be established at the start through competition over the awarding of the remote sensing "franchise."

Starting with the assumption that a private monopoly of remote sensing is also in the public interest, the question then becomes: "What public assurances are required to ensure that a private venture is economically viable, with a reasonable degree of risk?" This is as much a political as an analytical question, and thus must eventually be answered in the context of the policy development and approval process.

Possible Areas for Regulation

In the discussions of this section, no distinction is made between the legal requirements which might be embodied in a contract between the government and a private sector operator and requirements which might be spelled out (either by Congress or by the designated regulatory entity based on its general authority) in the form of actual regulations and regulatory policies. In practice, however, this distinction will be important, as it is likely to be easier to modify contract requirements on the basis of experience than to change formal regulatory requirements.

Candidates for regulation include: pricing policies, conditions of service, conditions of access to system output, role of system operator in associated ventures, technical standards for various system products, requirements for coordination and complementarity with non-U.S. systems, adherence to international law and treaties, adherence to national security constraints, provisions for government

access or takeover in times of national emergency, insider use of remote sensing information, export control constraints, etc. The list is long and the requirements complex and not always consistent. The public interests involved are significant, but the danger of overregulation undermining the viability of a private venture is real. Thus decisions on the nature and degree of regulation are likely to be difficult and subject to challenge. This is another reason for a flexible regulatory approach as the system evolves.

<u>Possible Areas for Government Assistance</u>

Since currently the federal government acquires a large portion of the distributed information products, the fundamental assistance that the government can provide to a private operator is guaranteeing to meet government needs by purchasing remote sensing products from a single U.S. operator, rather than procuring them on a competitive basis from other U.S. or international providers. The time span of this guarantee and its specific provision will be a subject of negotiation as the private venture evolves. However, questions which will inevitably be raised include:

- Can the U.S. government pledge to purchase a specified amount of anything from a private supplier well into the future, when the funds for such purchases have not been appropriated? Or must the pledge be to purchase all of government's needs from a single supplier, without a guarantee of a minimum amount of business?
- What will happen to government purchase requirements if the private operation is successful? Is unsuccessful? In the former case, will government incur a reduced purchase obligation, or a reduction in price? Will there be any kind of profit-sharing? In the latter case, will there be "bail out" provisions which will increase the cost to government of assisting the system? What are the government's obligations to a failing system?

In addition to long-term purchases of system products, government can provide a number of other forms of legal and regulatory assistance to a private operator. These include:

- Providing copyright or other form of proprietary protection so that the private operator can control dissemination of remote sensing products; this protection would have to extend to the operation of foreign ground stations and purchases by non-U.S. uses.
- Waiving Freedom of Information Act provisions so that the government does not have to provide to the general public copies of products which the government purchases for its own needs.
- Agreeing on terms for government use of its purchases. Will several agencies be able to share a single product, or must each agency pay for its own needs?

- Providing protection from legal actions initiated by potential competitors. What will be the anti-trust context in force if the government creates and maintains over time a monopoly relationship with a single remote sensing venture?
- Helping the private operator in market development vis-a-vis, on one hand, such potential users as state and local governments and research institutions and, on the other, overseas markets which might result from U.S. government technical assistance programs or export promotion efforts.
- Protecting the U.S. operator against unfair foreign competition in third-country markets or in the nongovernment share of the U.S. market.

As the above discussion suggests, questions arising from the necessary relationship between the U.S. government and any private system operator will be persistent and multifaceted. In order to carry out the government role in this partnership, an effective institutional mechanism or mechansims must be chartered. The following section discusses this and other institutional issues.

7.5 Institutional Issues

It should be clear at this point in the discussion that any particular institutional format chosen for a land remote sensing satellite system would be derived from answers to a series of questions regarding the kind of political, international, legal/regulatory and national security implications identified above. Whether the system is government owned, quasi-governmental or privately owned by either competitive or monopolistic entities, there is no doubt that there will be vested in it such organizational devices as are deemed necessary by the government to assure that relationships between the system's operator and various public, foreign policy and national security interests are preserved. It is most likely that the organizational framework for the U.S. land remote sensing satellite system which is selected will be that which best embodies the dominant set of political, social and economic philosophies of the time, rather than a structure determined analytically to be optimum.

Therefore, detailed attention is not paid in this section to an analysis of a variety of organizational alternatives. This is simply because institutional issues appear to be somewhat secondary when compared to other nonfinancial issues. Given an agreement within Congress and the Executive Branch on what political, social and economic parameters should guide the establishment of the system, there is little doubt that a viable framework for the operational land remote sensing system can be designed. A historical example of such organizational

innovation was the creation of the Communications Satellite Corporation (COMSAT). Once majority agreement was reached during the economic and political debate which occurred in the summer of 1962 over the appropriate framework for commercializing communication satellites, it was possible to design an innovative organizational form which was satisfactory to most of the participants in the debate. There is no reason to think that in the case of the land remote sensing satellite system the situation will be any different. Much of the controversy over various organizational forms in the case of both COMSAT and now land remote sensing, it appears, has actually been as a surrogate for debate over more fundamental issues of economic and political philosophy.

There are several comments which can be made with respect to institutional aspects of the remote sensing issue. One is that the structure of the federal government has proved ill-matched to the task of developing and demonstrating a system which would lead to commercialization. A R&D agency, NASA, was responsible for the early stages of the U.S. land remote sensing program, and its actions in retrospect appear driven as much by considerations of engineering development as by those of user requirements and market opportunities. The interim government operator of the system, NOAA, has had little opportunity to demonstrate whether it can be successful in creating a more user-oriented, operational style for the LANDSAT program. Many different federal agencies, particularly Argiculture, Interior and the Central Intelligence Agency, are users of remote sensing data, but they have differing needs and priorities vis-a-vis remote sensing, and none seem willing to make long-term commitments to data purchases and to using the output of the system in ways critical to their respective missions. This may be partly due to the lack of guarantee of continuity of service. A major argument against keeping remote sensing within a governmental framework (in addition to economic and political factors) is the limited evidence to date that this will result in a successful U.S. system in the long run.

A second set of institutional issues relates to the government's role vis-a-vis any privately operated system. According to current policy,* the Department of Commerce (specifically, it would seem NOAA/NESDIS) will have responsibility for aggregating government requirements, specifying the conditions under which a private system will operate, and developing and implementing the regulatory

*White House Fact Sheet, "National Space Policy."

framework for the system using the authority provided by Congress as part of the legislation transferring the operating franchise to a private entity. The point here is that NOAA has limited experience in any of these roles, and some sort of institutional and staff modifications are likely to be necessary to provide the capabilities required.

7.6 General Policy Issues

This review of the various categories of nonfinancial issues has led to the identification of several major policy concerns related to the viability of the remote sensing venture; to the R&D requirements for the future success and continuity of the system; and to the balance between public, governmental and private interests.

In determining the appropriate institutional location for the permanent system, decisions must be made as to the extent of responsibility that the government will assume. For example, under continued government ownership and operation, commitments must be made to uses which may necessitate re-examination of long-term budgetary requirements for affected agencies. Under private sector control, criteria need to be set which will outline the extent of the financial obligations the government may have with the private sector entity, including provisions for possible failure of the system due to successful competitive pressure or to general lack of demand for its products. For example, will government be asked to nationalize a failing venture because of its importance to national and societal interests, as well as to private interests? When a private venture is threatened by economic competition from overseas systems, will the government adopt protectionist policies? Will the government's positive role include expanding international markets? What steps and policy requirements would be required in the case of technical failure of the system? How much redundancy in the system will be required of a private operator, or even a government-operated system, in order to assure data continuity? Will government retain the right to step in and launch its own satellites or to assume some sort of managerial control over the private venture in the event of failure, economic or technical, of the private sector operator?

It is assumed that research on advanced remote sensing technology will continue to be carried out under government auspices, either through an active civilian R&D program or in the context of meeting national security requirements.

Yet the extent and conditions for transfer of such government-developed technologies to a privately operated system is unclear. Government has not yet made an explicit commitment to continue R&D on sensor and processing technologies if operation of the land remote sensing system is in commercial hands. In the case of communications satellites, the United States withdrew from R&D in related technologies in the early 1970s on the grounds that since the private sector was operating communications satellites, they should also be responsible for the R&D required for future systems. This policy was reversed under the Carter Administration, and NASA in recent years has resumed its communications satellite R&D efforts. The grounds given for this policy reversal was that the private sector was not doing the basic work required to keep the U.S. competitive vis-a-vis other industrial countries.

This suggests that a program of continued government R&D cannot, in fact, be assumed; NASA priorities may well point elsewhere. Other problems likely to characterize any continued relationship between government and a private sector operator in the area of R&D pertain to how decisions on the R&D are to be made and by whom. For instance, who is to determine what areas of R&D are most important and who is to say when a new technology is "operational?" Also, what restrictions are to be placed upon use within government of products resulting from R&D efforts, since potentially these could undercut the government market for existing remote sensing imagery.

Of overriding importance is the recognition that there are both public and private interests in land remote sensing and that the two do not necessarily always coincide. It is important in assessing alternative systems to pay proper attention to determining the appropriate balance between public and private interests. This balance must be not only achieved prior to transfer, but should also be assessed throughout the subsequent life of the system.

In deciding on a strategy appropriate for transfer to private operation, it is important to keep in mind the fact that the public has invested well over a billion dollars in the development of this capability to date. There are certain expectations, irrespective of recoupment considerations, about the continued responsiveness of the system to public interests. These expectations will persist whether the system is handed over to a monopoly, to competitive enterprise or is designed in the formation of a public corporation. Numerous political difficulties and conflicts might arise if transfer to a private operator is attempted without some form of

meaningful competition. One reason for this lies with basic problems in designing a regulatory entity which is effective in its performance of its public responsibilities and assigned duties. If transfer is through a noncompetitive, sole-source award, problems may develop as a result of the "captivity" that sometimes occurs when a single body functions as both user and regulator of the activities of an industry.

On the other hand, the interests of any private sector operator of remote sensing must also be protected. Various foreign policy, international, national security or domestic interest must be addressed, yet regulations should be tempered by concerns of commercial viability and economic stimulation. Care must be taken to ensure that the private entity is not overregulated and is able to operate over time in an efficient and profitable manner.

7.7 Policy Requirements - A Summary

Whatever scenario is followed for creating a permanent operational framework for the U.S. remote sensing system, it seems that government policy dealing with the following must be developed by the cooperative efforts of Congress and the Executive Branch:

- Providing for system continuity (or of ways of dealing with discontinuities) - Full potential of remote sensing applications and markets will never be achieved unless users can depend on having the kind of system output they need available when they need it.
- Setting data policy - Although the substance of a data policy may differ depending on the overall framework selected, the government will have to decide what kind of influence it wishes to exert on parameters such as price of system products, conditions of access to those products and technical standards for system performance.
- Relating a U.S. system to other systems, to non-U.S. users, and to international political and legal factors - There is an inescapable international dimension involving cooperation, coordination and competition to any remote sensing enterprise. How international aspects will be integrated into system operation will remain a continuing policy challenge.
- Developing a regulatory framework for system operation - Any system operator will have to manage a remote sensing enterprise within limits and requirements set by government. That framework should reflect balanced agreement with respect to a variety of conflicting national goals, objectives and interests relevant to remote sensing activities.

Reaching agreement on such a policy framework, given other financial and nonfinancial issues reviewed so far in this report, will require creative policy making and a willingness to compromise, negotiate and "satisfice" with respect to the many private sector and public sector interests connected to remote sensing.

The previous sections of this report reviewed several scenarios for setting up a permanent framework, with an eye to determining whether one or another of these scenarios is more likely to facilitate the needed agreement. As has been said several times in this section, many of the choices to be made are choices between conflicting goals and values, and thus are the kind of choices best made for society through its legitimate political authorities.

8. OBSERVATIONS/CONCLUSIONS

Benefit and cost effectiveness studies performed over the past decade have concluded that the potential benefits from a LANDSAT system would be on the order of hundreds of millions to a billion dollars annually [26-29]. With these large potential benefits an obvious question is why has commercialization not taken place? A likely answer to this question is that a public sector undertaking, such as the LANDSAT program, can be justified if it can be shown that the potential benefits from the program exceed program costs. The benefits are to the public at large and there need not be a convenient mechanism for charging for benefits provided. The public sector's objective is to maximize societal benefits. A private sector business venture may provide the same public benefits but the benefits of concern are those obtained by the business venture in the form of profits. The private sector objective is profit maximization.

It is very often the case that the objectives of profit maximization and benefit maximization do not coincide. This is normally the case when there is a lack of pricing mechanisms that relate to benefits. To illustrate, consider a system that improves emergency communications in rural areas. Studies have shown that this could lead to thousands of lives saved annually having economic value to society of hundreds of millions to billions of dollars. However, commercialization is not likely to occur specifically for this application because there does not appear to be a pricing mechanism that can be related to the value of lives saved.

For a business to achieve a profit requires revenue which in turn implies a pricing mechanism. Unfortunately, many of the potential benefits from land remote sensing have not been linked by a pricing mechanism; in other words they are a public good. To date it appears that pricing mechanisms have only been established based upon budgets that have been developed over time for providing a service (for example, obtaining imagery that will assist in the location of mineral deposits, and collecting wheat yield data and producing crop forecasts)—the value of LANDSAT data has basically been equated with the cost of collecting similar data by other means. Generally, budgets have not been increased because of the "added capability" or added value of the information products to society. Thus the markets to date for LANDSAT type products have been related to existing data collection budgets. New or increased markets will only develop as an appreciation

develops for the added capability and added value of the LANDSAT type products. When budgets are not increased to the point where net benefits are maximized through private sector actions, government participation through ownership and operation or subsidization may be appropriate in order to achieve the societal benefits that might otherwise be foregone.

The observations and conclusions that may be drawn from the analyses reported in the previous pages have been grouped into the categories of Operations, Financial and Nonfinancial. These are discussed below.

8.1 Observations/Conclusions: Operations

LANDSAT D is currently providing land observation data. It has a finite life—possibly three years. When D fails it will be replaced with D'—this is not a certainty since launch reliability is not 100 percent. If D' is placed into orbit successfully it is likely to last two to three years. If action is not taken swiftly, it is likely that both D and D' will have failed before a replacement is possible. This series of events, coupled with the expected competitive SPOT and other systems and the need for uninterrupted service, poses a dilemma.

First the need for uninterrupted service. Certain users (both U.S. and foreign) have come to rely on LANDSAT information products. An interruption in service may cause these users to revert back to pre-LANDSAT operations or to seek similar data from other sources, for example SPOT. Since the market (assuming uninterrupted service) for LANDSAT products is anticipated to be insufficient for commercialization, government support will be required to achieve a goal of commercialization. Therefore a loss of any piece of the market (because of an interruption in service) can be significant and would have to be made up by additional government support.

The dilemma is that the anticipated sequence of events dictates that rapid decisions be made with respect to commercialization or retention. Insufficient information currently exists upon which to make the necessary informed decisions. Because of the magnitude of the costs and expenditures and procurement times associated with remote sensing, inappropriate decisions may not be reversed for a decade or more. On the other hand, informed decisions imply time delays while the necessary information is obtained upon which to base these decisions. Delays increase the likelihood of service interruption. Therefore, informed decisions imply the need for an additional spacecraft to backup LANDSAT D'. This must be

initiated immediately if there is to be a high likelihood of continuity of service. It should be noted that doing nothing implies either phase-out or interruption in service—both are good for competitive systems.

The inability to be specific about launch vehicle cost is a contribution to the uncertainty surrounding a possible commercial venture. NASA has not established definitive plans with respect to the support of the DELTA launch vehicle beyond FY 86. Commercialization of the DELTA and other expendable launch vehicles is uncertain. Shuttle pricing policy for WTR launches has not yet been established. Ariane is a possible alternative. This uncertainty with respect to the availability and cost of launch vehicles will affect private sector investment decisions.

8.2 Observations/Conclusions: Financial

There are many possible business systems that may be considered as commercialization of the civil land remote sensing program. These range from short duration flights of Space Shuttle launched instruments with marketing and sale of collected data, to a combined land and weather remote sensing operational system with marketing and sale of information and value added products. Because of time constraints only one business system was considered in this study and this was not necessarily the best. The specific business system was based upon providing uninterrupted service resulting from the continued use of LANDSAT D and D' phasing in, slightly before the demise of D', new satellites with 80M and later 30M sensors having stereoscopic capability. The following commercialization or retention options were evaluated and compared under the above business system:

- Continued ownership and operation by the federal government (planned phase-out)
- Continued ownership and operation by the federal government (establishment of the necessary budgetary line items)
- Wholly privately-owned and operated by an entity competitively selected
- Phased private ownership (government ownership and operation with private sector marketing)
- Legislatively-chartered, privately-owned corporation.

The analysis of these scenarios was developed based upon the same demand forecast and the same schedule of events. Government net cash flows were developed in all cases. For the private sector scenarios, financially viable business

initiated immediately if there is to be a high likelihood of continuity of service. It should be noted that doing nothing implies either phase-out or interruption in service—both are good for competitive systems.

The inability to be specific about launch vehicle cost is a contribution to the uncertainty surrounding a possible commercial venture. NASA has not established definitive plans with respect to the support of the DELTA launch vehicle beyond FY 86. Commercialization of the DELTA and other expendable launch vehicles is uncertain. Shuttle pricing policy for WTR launches has not yet been established. Ariane is a possible alternative. This uncertainty with respect to the availability and cost of launch vehicles will affect private sector investment decisions.

8.2 Observations/Conclusions: Financial

There are many possible business systems that may be considered as commercialization of the civil land remote sensing program. These range from short duration flights of Space Shuttle launched instruments with marketing and sale of collected data, to a combined land and weather remote sensing operational system with marketing and sale of information and value added products. Because of time constraints only one business system was considered in this study and this was not necessarily the best. The specific business system was based upon providing uninterrupted service resulting from the continued use of LANDSAT D and D' phasing in, slightly before the demise of D', new satellites with 80M and later 30M sensors having stereoscopic capability. The following commercialization or retention options were evaluated and compared under the above business system:

- Continued ownership and operation by the federal government (planned phase-out)
- Continued ownership and operation by the federal government (establishment of the necessary budgetary line items)
- Wholly privately-owned and operated by an entity competitively selected
- Phased private ownership (government ownership and operation with private sector marketing)
- Legislatively-chartered, privately-owned corporation.

The analysis of these scenarios was developed based upon the same demand forecast and the same schedule of events. Government net cash flows were developed in all cases. For the private sector scenarios, financially viable business

ventures were developed based upon achieving return on capital and other financial measures deemed necessary to achieve financing. The required rates of return were obtained through the use of government subsidies.

Underlying all of the commercialization or retention scenarios is a market or demand forecast that is characterized by great uncertainty. This is due to an insufficient understanding of the relationship of demand to information product attributes such as price, resolution, and number and location of spectral bands. Government actions with respect towards emphasizing or encouraging the use of land remote sensing information may significantly influence demand. This is extremely important since there appears (for the business scenario considered) to be insufficient demand for commercialization to take place without significant government involvement through ownership and operation, subsidization or a combination of both.

A basic decision that has to be made is whether or not the government will continue to participate through ownership and operation and/or subsidization or will withdraw from the remote sensing scene. Withdrawal implies a continuing cost either through the acquisition of information products or through benefits foregone. Withdrawal decreases the likelihood of commercialization which in turn is likely to result in price increases from SPOT or other systems through reduced competition. Government withdrawal (Phase-out) can be the lowest cost alternative _if_ potential benefits are not significantly larger than costs and the cost of information products does not rise significantly.

Figure 8.1 summarizes the present value of government cash flow and average annual government cost associated with each of the considered commercialization or retention scenarios. The cash flow and costs take into account government expenditures such as payments for information products, operations costs, R&D cost, subsidy payments and equity purchases. These may be offset by receipts (from the private sector) in the form of lease payments, asset recoupment payments, TDRSS fees, profit sharing or royalty on sales, generated tax revenue and dividends. It is clear, for the business scenario considered, that government phase-out can be the lowest cost (from a direct budgetary point of view, not necessarily from a benefits point of view) alternative. When considering continuation of LANDSAT, the continued government ownership and operation scenario results in the lowest cost approach. The government costs increase, though not at

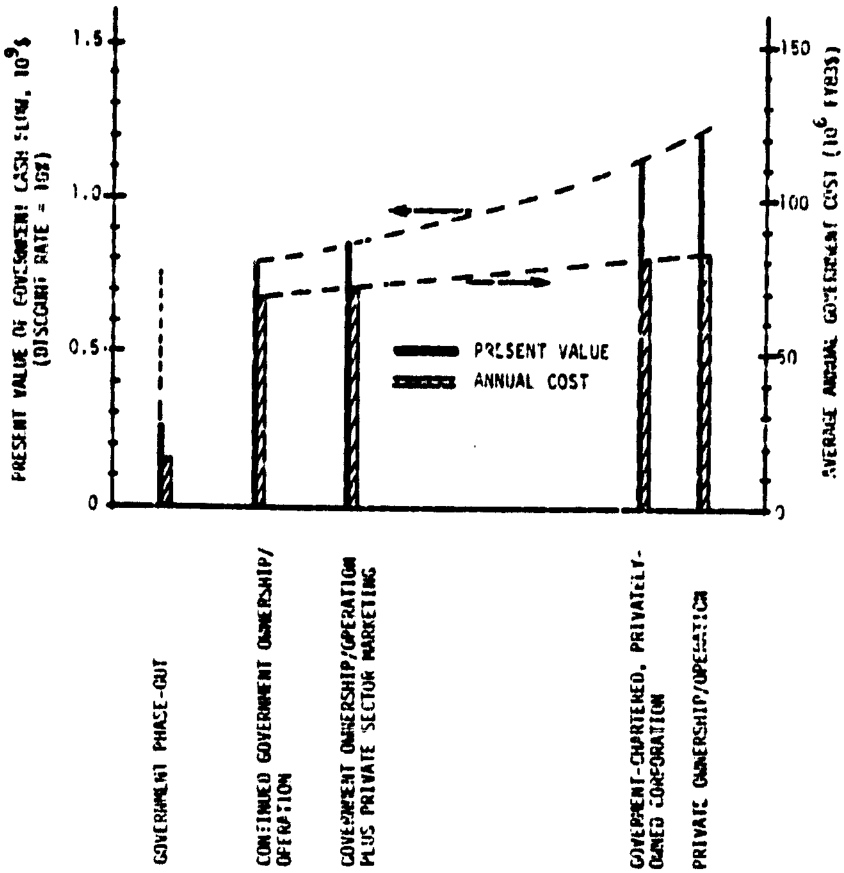


FIGURE 8.1 PRESENT VALUE OF GOVERNMENT CASH FLOW AND GOVERNMENT AVERAGE ANNUAL COST AS A FUNCTION OF COMMERCIALIZATION OR RETENTION SCENARIO (FULL GOVERNMENT RECOUPMENT)

what might be considered a significant rate, as private sector involvement increases and government operational involvement decreases. It should be noted that *if* private sector operations can be conducted more efficiently than similar government operations then the indicated costs would be reduced as private sector involvement increased (i.e., the slope of the dashed lines decreases and the lines pivot about the continued government ownership/operation costs). It should also be noted that, in general, as the private sector involvement increases so does the significance and complexity of nonfinancial issues.

Government costs associated with continuation of land remote sensing, are anticipated to vary only slightly with the commercialization or retention scenarios. It is anticipated that government annual costs will average on the order of $70 to $80 million (FY83$) through, and possibly beyond, 1994. The effect of asset

transfer and recoupment policy appears to be minimal. For example, for the private ownership and operation scenario, the present value of government costs is $1200 million with full repayment (recoupment) for government assets utilized by the private sector vs. $1193 million with no recoupment. Average annual government cost (constant FY83$) is $82 million with recoupment vs. $81 million without recoupment. The effect of return on equity and cost of borrowing is somewhat more significant though not a major factor. Reducing required return on equity and the cost of borrowing by approximately 20 percent (from return on equity of 17 percent and cost of borrowing of 11 percent to 14 percent and 9 percent respectively) reduces average annual government cost from $82 million to $75 million (constant FY83$) for the private ownership and operation scenario.

Based upon the financial results, it is possible to make a plausible case that full transfer to the private sector with the expectation of a viable, self-sustaining enterprise is premature by a number of years. Thus, if it is desired to continue land remote sensing then it is possible to argue that either

- There is a justification for unusual degree of government support for transfer recognizing the high value of land remote sensing information products, the possible lack of pricing mechanisms that reflect this value and the resulting high risk character of transfer to the private sector, or

- There is a need for continuing government leadership in this area with a limited but possibly gradually increasing private sector role.

In addition to examining government costs, the alternatives to government retention were studied from the perspective of a potential private sector investor. In order to attain an acceptable rate of return, the alternatives to government retention involve either significant subsidy, or if the private sector takes on the marketing function, continued government ownership and operation of the space and ground segments. Of the private sector options considered, the latter appears to be the most attractive from the standpoint of financing (size of investment); however, all of the options to government retention share a complex set of nonfinancial problems. On the other hand, should the government choose to phase-out LANDSAT operations, from a purely financial standpoint, it is not likely that the private sector in the U.S. will step in and provide the same services that are currently furnished by the federal government without some form of subsidy.

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE 8.1 NONFINANCIAL ISSUES: COMPARATIVE ANALYSIS

SCENARIO / CATEGORY OF ISSUE	GOVERNMENT OWNERSHIP: CONTINUATION	GOVERNMENT OWNERSHIP: TERMINATION	PHASED-IN PRIVATE OWNERSHIP
INTERNATIONAL AND FOREIGN POLICY	• BUILDS ON ESTABLISHED PATTERNS OF INTERACTION, CURRENT POLICY OF OPEN ACCESS, AND AGREEMENTS WITH FOREIGN OPERATORS OF GROUND STATIONS • FACILITATES USE OF REMOTE SENSING TECHNOLOGY AS INSTRUMENT OF FOREIGN POLICY • EASIER TO COORDINATE FOREIGN POLICY ACTIVITIES WITH OPERATIONAL CONCERNS • LEAST LIKELY TO PROVOKE INTERNATIONAL POLITICAL REACTIONS AND RESULTANT CONFLICT • U.S. POSITION VIS-A-VIS COMPETING SYSTEMS DETERMINED THROUGH FEDERAL BUDGET PROCESS • MAY GIVE U.S. POLITICAL LEVERAGE IN FUTURE	• FORFEITS TO OTHERS, PARTICULARLY NON-U.S. OPERATORS, ANY POLITICAL BENEFITS WHICH MAY RESULT FROM SYSTEM OPERATION • TEMPORARY NEGATIVE REACTIONS AS U.S. GOVERNMENT WITHDRAWS FROM EARLIER COMMITMENTS (E.G., TO GROUND STATION OPERATORS) AND PATTERNS OF ACTION (E.G., FOREIGN ASSISTANCE PROGRAMS BASED ON REMOTE SENSING DATA) • DIMINISHES U.S. LEVERAGE ON INTERNATIONAL DEBATE OVER REMOTE SENSING PRINCIPLES • AIDS U.S. OF POTENTIAL POLITICAL LIABILITY IF PROTESTS OVER SENSING WITHOUT CONSENT INCREASE	• MOST AREAS WITH INTERNATIONAL SENSITIVITY STILL UNDER GOVERNMENT CONTROL; GOVERNMENT COULD TAKE LEAD IN INTERNATIONAL NEGOTIATIONS • MAY CREATE OVERSEAS MARKET FOR U.S. PRIVATE SECTOR IN BOTH DATA PROCESSING AND DISSEMINATION AND "VALUE-ADDED" SERVICES • COULD COMPLICATE RELATIONSHIPS WITH FOREIGN GROUND STATION OPERATORS • POSSIBLE TENSIONS BETWEEN OPEN ACCESS DATA POLICY AND OBJECTIVES OF PRIVATE SECTOR MARKETING ORGANIZATION • GOVERNMENT COULD DETERMINE LEVEL OF INVESTMENT NEEDED TO MAINTAIN U.S. LEADERSHIP IN REMOTE SENSING TECHNOLOGY
NATIONAL SECURITY	• FACILITATES NATIONAL SECURITY INPUT INTO SYSTEM OPERATION AND EVOLUTION • MAINTAINS SEPARATION BETWEEN CIVILIAN AND NATIONAL SECURITY EARTH OBSERVATION PROGRAMS • MAY INHIBIT SYSTEM DEVELOPMENT BECAUSE OF NATIONAL SECURITY CONSTRAINTS • EASIER TO DEAL WITH CONFLICTS BETWEEN EXPORT CONTROL AND SYSTEM DEVELOPMENT OBJECTIVES	• REMOVES "COVER" OF OPEN CIVILIAN PROGRAM FOR OPERATION OF NATIONAL SECURITY OBSERVATION SYSTEM • LESSENS LIKELIHOOD OF LEAKAGE OF SENSITIVE INFORMATION/TECHNOLOGY THROUGH CIVILIAN CHANNELS • REMOVES ONE SOURCE OF POTENTIALLY USEFUL DATA FOR NATIONAL SECURITY AGENCIES	• LIKELY TO MAINTAIN NATIONAL SECURITY BENEFITS OF "OPEN SKIES" POLICY • GOVERNMENT CAN CONTROL THOSE ASPECTS OF SYSTEM TECHNOLOGY AND OPERATION MOST SENSITIVE FROM NATIONAL SECURITY PERSPECTIVE • GOVERNMENT NEEDS RELATED TO NATIONAL SECURITY COULD BE FULFILLED WITHOUT PRIVATE SECTOR INVOLVEMENT • SOME TENSIONS BETWEEN CONSTRAINTS ON SYSTEM EVOLUTION AND ECONOMIC COMPETITIVENESS OBJECTIVES
LEGAL/REGULATORY	• WILL REQUIRE SOME FORM OF PROPRIETARY CONTROL OVER DATA PRODUCTS, IF COST RECOVERY IS A GOAL • NO REGULATORY MECHANISM REQUIRED SINCE SYSTEM IS OPERATED WITHIN GOVERNMENT ACCORDING TO ESTABLISHED POLICY	• WILL REQUIRE NEGOTIATED PHASE-OUT OF EXISTING CONTRACTS AND INTERNATIONAL AGREEMENTS	• REQUIRES COMPLEX AND UNPRECEDENTED LEGAL RELATIONSHIP BETWEEN GOVERNMENT AND PRIVATE SECTOR ENTITY AS PARTNERS IN PROFIT-SHARING VENTURE • PROPRIETARY RESTRICTIONS ON SYSTEM OUTPUT MAY BE REQUIRED; DOES MARKETING ORGANIZATION HAVE EXCLUSIVE ACCESS? • COPYRIGHT OR OTHER PROPRIETARY CONTROLS ON PROCESSED DATA PRODUCTS AS WELL AS "VALUE ADDED" PRODUCTS • LESS OVERALL REGULATION REQUIRED THAN IN OTHER PRIVATE SECTOR SCENARIOS • WILL MARKETING ORGANIZATION BE EXCLUDED FROM "VALUE ADDED" BUSINESS?
INSTITUTIONAL	• WILL REQUIRE LARGER CIVIL SERVICE CADRE THAN OTHER SCENARIOS • REMOTE SENSING CAPABILITIES NOT GOOD TO FIT TO STRUCTURE OF GOVERNMENT AGENCIES, CONSTANT NEED FOR INTERAGENCY COORDINATION • RECORD OF FEDERAL OPERATION TO DATE NOT EXCELLENT, BUT NOAA A NEWCOMER TO ROLE	• REDUCES CIVIL SERVICE WORK FORCE AND GOVERNMENT R&D AND SYSTEM OPERATING BUDGETS—WILL STILL REQUIRE BUDGET FOR PURCHASE OF INFORMATION FROM NONGOVERNMENT SUPPLIER, UNLESS FEDERAL USERS STOP ALL USES OF DATA ACQUIRED BY REMOTE SENSING; THEN BENEFITS (INCLUDING NONFINANCIAL ONES) ARE FOREGONE	• WILL RESULT IN SOME DECREASE IN CIVIL SERVICE WORK FORCE AND COULD RESULT IN MEANINGFUL NET BUDGET SAVINGS • LITTLE PRECEDENT IN STRUCTURING RELATIONSHIP BETWEEN GOVERNMENT-OPERATED SYSTEM AND PRIVATE SECTOR MARKETING ORGANIZATION
GENERAL POLICY/ POLITICAL	• REFLECTS DECISION THAT SYSTEM BENEFITS ARE PRIMARILY PUBLIC GOODS AND THUS PROPERLY PROVIDED BY GOVERNMENT • NOT ENOUGH INFORMATION AVAILABLE TO EVALUATE LIKELY IMPACT OF TRANSFER TO PRIVATE SECTOR • WILL REQUIRE LONG-TERM COMMITMENTS ON PART OF SEVERAL AGENCIES IF SYSTEM CONTINUITY IS TO BE ACHIEVED • PRESUMES CONTINUING GOVERNMENT R&D PROGRAM	• REFLECTS FAILURE OF GOVERNMENT R&D AND DEMONSTRATION EFFORTS LASTING ALMOST TWO DECADES; THIS HAS POLITICAL COSTS	• ENHANCES CHANCE OF COMMERCIAL SUCCESS BY KEEPING HIGH COST ELEMENTS WITHIN GOVERNMENT • IMPLIES CONTINUING GOVERNMENT R&D PROGRAM; WHAT R&D WOULD PRIVATE ORGANIZATION DO? • GOVERNMENT GUARANTEES CONTINUITY, SYSTEM PERFORMANCE, ETC.; PRIVATE SECTOR ORGANIZATION PROFITS FROM THEM—IS THIS POLITICALLY ACCEPTABLE? • PRIVATE SECTOR GUARANTEES A MINIMUM PAYMENT TO GOVERNMENT

TABLE 8.1 NONFINANCIAL ISSUES: COMPARATIVE ANALYSIS (CONTINUED)		
SCENARIO / CATEGORY OF ISSUE	COMPETITIVELY-SELECTED PRIVATE OPERATOR	GOVERNMENT-CHARTERED PRIVATELY-OWNED CORPORATION
INTERNATIONAL AND FOREIGN POLICY	• REDUCES OPPORTUNITY TO PURSUE FOREIGN POLICY OBJECTIVES THROUGH REMOTE SENSING PROGRAM • LIKELY, AT LEAST DURING TRANSITION FROM GOVERNMENT SYSTEM, TO PRODUCE TENSIONS AND COMPLAINTS FROM FOREIGN COUNTRIES OVER PRIVATE CONTROL OF THIS KIND OF CAPABILITY • MAKES PRIVATE SECTOR ORGANIZATION RESPONSIBLE FOR HONORING U.S. GOVERNMENT PLEDGES, E.G., OPEN, NONDISCRIMINATORY ACCESS • RELATIONSHIP WITH FOREIGN GROUND STATIONS RENEGOTIATED IN CHANGED CONTEXT • U.S. GOVERNMENT SUPERVISION REQUIRED FOR ADHERENCE TO INTERNATIONAL TREATIES AND OTHER OBLIGATIONS • U.S. GOVERNMENT MAY STILL HAVE TO NEGOTIATE INTERNATIONAL FRAMEWORK FOR SYSTEM OPERATION • U.S. LEADERSHIP DEPENDENT ON PRIVATE SECTOR PERFORMANCE	• CLOSER LINK TO U.S. GOVERNMENT INTERESTS CAN BE DESIGNED INTO ORGANIZATION FROM START; THIS MAY LESSEN BUT NOT ELIMINATE CONFLICTS BETWEEN FOREIGN POLICY INTERESTS AND COMMERCIAL INTERESTS • OTHERWISE, MUCH THE SAME AS COMPETITIVELY-SELECTED OPERATOR
NATIONAL SECURITY	• CONTINUING TENSIONS BETWEEN NATIONAL SECURITY CONSTRAINTS AND OBJECTIVES OF COMMERCIAL SUCCESS • MAY MAKE IT MORE DIFFICULT FOR U.S. GOVERNMENT TO OPERATE CLASSIFIED OBSERVATION SYSTEMS • PRIVATE OPERATOR LESS RESPONSIVE TO NATIONAL SECURITY INTERESTS, NEEDS	• RESPONSIVENESS OF ORGANIZATION TO NATIONAL SECURITY REQUIREMENTS MAY BE GREATER, AT LEAST INITIALLY • OTHERWISE, MUCH THE SAME AS COMPETITIVELY-SELECTED OPERATOR
LEGAL/REGULATORY	• WILL REQUIRE SIGNIFICANT OVERSIGHT IF PUBLIC INTEREST IS TO BE MAINTAINED AS HIGH PRIORITY IN SYSTEM OPERATION • DIFFICULT TO DESIGN CONTRACT PROVISIONS ACCEPTABLE TO BOTH PRIVATE SECTOR OPERATOR AND POLITICAL AUTHORITIES • DIFFICULT ISSUES OF ANTI-TRUST, GOVERNMENT PROTECTION OF A MONOPOLY, TREATMENT OF POTENTIAL COMPETITORS • NEED TO DETERMINE GOALS AND DETAILS OF REGULATORY FRAMEWORK—MINIMAL OR SUBSTANTIAL REGULATION? • NEED FOR REGULATORY FLEXIBILITY AS PRIVATE SYSTEM EVOLVES • CHARACTER OF GOVERNMENT ASSISTANCE/SUBSIDY AND ITS LEGAL CHARACTER DIFFICULT TO ESTABLISH	• SOME ASPECTS OF REGULATORY FRAMEWORK CAN BE MADE PART OF ORGANIZATION'S CHARTER; STATUS AS DESIGNATED ENTITY IMPLIES CLOSER RELATIONSHIP TO PUBLIC INTERESTS • STATUS VIS-A-VIS POSSIBLE COMPETITION CAN BE SETTLED AT TIME ORGANIZATION IS CHARTERED • EASIER TO CREATE AND MAINTAIN EFFECTIVE GOVERNMENT-PRIVATE SECTOR PARTNERSHIP
INSTITUTIONAL	• NET DECREASE IN CIVIL SERVICE WORK FORCE, BUT NEED TO CREATE AND STAFF A REGULATORY OFFICE • CONTRACT NEGOTIATION AND MONITORING A CONTINUING TASK, AS IS AGGREGATING FEDERAL PURCHASES	• NET DECREASE IN CIVIL SERVICE WORK FORCE, BUT SOME CONTINUING GOVERNMENT INVOLVEMENT IN OVERSIGHT OF OPERATION • WILL REQUIRE ORGANIZATIONAL CREATIVITY TO DESIGN SUCCESSFUL AND POLITICALLY ACCEPTABLE STRUCTURE, SINCE MANY VALUE CONFLICTS MUST BE RESOLVED IN THAT DESIGN
GENERAL POLICY/ POLITICAL	• REFLECTS DECISION THAT SYSTEM BENEFITS, WHILE MIXED, HAVE ENOUGH PRIVATE GOODS CHARACTERISTICS TO EVENTUALLY BE BASIS FOR COMMERCIALLY VIABLE ENTERPRISE; OR, IMPACT IN TRANSFER OF PUBLIC FUNCTION TO PRIVATE OPERATOR • REQUIREMENTS FOR VIABLE ENTERPRISE INVOLVE LONG-TERM GOVERNMENT COMMITMENTS WHICH MAY BE POLITICALLY FRAGILE • MAJOR BENEFIT COULD BE STIMULATION OF NEW AREA OF SERVICE INDUSTRY GROWTH • CONTINUING GOVERNMENT R&D PROGRAM APPEARS REQUIRED TO MAINTAIN U.S. LEADERSHIP • POSSIBILITY OF TECHNICAL OR COMMERCIAL FAILURE WOULD RAISE DIFFICULT ISSUES; WILL THERE BE A GOVERNMENT "BAIL OUT" POLICY?	• APPROACH SIMILAR TO CREATION OF COMSAT, BUT IN MUCH MORE DIFFICULT CONTEXT; NO ASSURANCE THAT IT IS POSSIBLE TO IDENTIFY BEST FRAMEWORK A PRIORI • WILL REQUIRE CONTINUING GOVERNMENT R&D PROGRAM AND GREATER GOVERNMENT GUARANTEES THAN IF COMPETITIVE SELECTION MADE • OTHERWISE, MUCH THE SAME AS COMPETITIVELY-SELECTED OPERATOR

ORIGINAL PAGE IS
OF POOR QUALITY

8.3 Observations/Conclusions: Nonfinancial

The many nonfinancial issues assume differing degrees of importance or significance for each of the commercialization or retention scenarios. These are summarized in Table 8.1.

Major nonfinancial issues are related to international, foreign policy and national security factors. Earth observation is a particularly sensitive activity internationally because nations take the concept of sovereignty seriously. Information obtained on national resources is recognized as increasingly valuable. All of this implies that any framework selected for commercialization should include maximum assurance that no international conflicts will be created and no U.S. security or foreign policy interests unnecessarily compromised. Thus, any private system will need fairly close government oversight with respect to its international aspects. Otherwise, significant potential exists for international problems.

The history of earth observation as government-developed technology and mixed public good/private good character of benefits from remote sensing combine to make transition to successful nongovernmental framework for operation particularly difficult. Requirements for commercial success may include politically fragile government guarantees and policy actions. Thus, maximum flexibility to revise public/private relationship and conditions under which system operator functions should be retained in designing the initial framework for the system.

9. RECOMMENDATIONS

The following recommendations are presented based upon the premise that commercialization issues will persist.

Because of the importance of decisions relating to commercialization, and the compressed timeframe* for making these decisions which have long-term implications, it is recommended that a number of actions be immediately initiated so that informed decisions can be made. It should be noted that initiation (by the government) of procurement of another LANDSAT satellite (beyond D') would extend the window available for making the critical commercialization decisions and allow more time for insuring that correct decisions are made.

It is recommended that analyses of the mechanisms of carrying out the transfer of remote sensing systems to the private sector continue. Specifically, it is recommended that:

- An in-depth quantitative market analysis be undertaken that will lead to definitive market forecasts and provide an understanding of demand relative to information product price, resolution, number and location of spectral bands and other important product attributes.

It is also recommended that the analysis techniques reported herein be used to:

- Continue the analysis and evaluation of other scenarios for commercialization of civil land remote sensing systems and to consider the impact of other market forecasts
- Analyze and evaluate potential value-added business scenarios and to develop an understanding of their impact on and inclusion in commercialization scenarios
- Analyze and evaluate scenarios for the commercialization of the meteorological remote sensing system
- Analyze and evaluate scenarios for the commercialization of a combined civil land remote sensing system and a meteorological remote sensing system.

It is also recommended that, in anticipation of the need to competitively select a commercialization alternative, evaluation criteria be developed against which commercialization proposals may be evaluated and then compared on

---

*Driven by the timing of anticipated events such as the launch, operation and demise (after several years, if everything goes according to plan) of LANDSAT D' and the time required to acquire another LANDSAT satellite and have it available for launch as a backup to D'.

a common basis. The selection of criteria can have a significant effect on which alternative will be selected. Such criteria as minimization of government subsidies and maximization of societal benefits should be considered—these will most likely lead to the selection of significantly different alternatives. As part of this effort, sufficient analyses should be undertaken so that typical scenarios are developed in response to different postulated evaluation criteria.

Since it is likely that there is room for only one system for each major product class, and the selection of the "wrong" system may eliminate the possibility for a decade or more of achieving the "right" system, it is also recommended that an analysis be performed of the impact that near-term decisions may have on long-term options.

Finally, since the analysis and evaluation of proposals for commercialization will lead to the selection of a desired alternative, it is recommended that an in-depth analysis be performed of each proposed alternative to establish estimates of the likelihood of success (both technical and economic) since failure will at a minimum necessitate a government bail out, a discontinuity in service or, in the worst case, the total elimination of the service.

BIBLIOGRAPHY

[1] NASA News, Press Kit No. 82-100, LANDSAT D.

[2] Office of Technology Assessment, Congressional Board of the 97th Congress, Civilian Space Policy and Applications, June 1982.

[3] Communications Satellite Corporation (COMSAT), Commercialization of Civil Remote Sensing, Volume I: Response to Request for Information, October 22, 1982.

[4] ______, Commercialization of Civil Remote Sensing, Volume II: Supplementary Materials, July 14, 1982.

[5] U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Earth Satellite Service, "Some Thoughts on Commercializing Land Remote Sensing from Space," January 6, 1982.

[6] Interagency Task Force: National Aeronautics and Space Administration, Department of Commerce/National Oceanic and Atmospheric Administration, Department of Interior, Department of Agriculture, Department of Defense, Environmental Protection Agency, U.S. Army Corps of Engineers and Department of State, "Private Sector Involvement in Civil Space Remote Sensing," Volume 1: Report, June 15, 1979.

[7] "Private Sector Involvement in Civil Space Remote Sensing," Volume 2: Appendices, June 15, 1979.

[8] McElroy, John H., "Commercialization of the Civil Space Remote Sensing Systems - A Review," September 1982.

[9] U.S. House of Representatives, Ninety-seventh Congress, Second Session, Act H.R. 5890, P.L. 97-324, signed October 15, 1982.

[10] U.S. Senate, H.R. 5890, October 1982.

[11] U.S. House of Representatives, Committee on Science and Technology, Ninety-sixth Congress, First Session, Hearings before the Subcommittee on Space Science and Applications, "Earth Resources Data and Information Service," May 2 and 3, 1979.

[12] U.S. House of Representatives and U.S. Senate, Joint Hearings before the Subcommittee on Space Science and Applications of the Committee on Science and Technology and the Subcommittee on Science, Technology and Space of the Committee on Commerce, Science and Transportation, Ninety-seventh Congress, First Session, "Civil Land Remote Sensing Systems," July 22 and 23, 1981.

[13] U.S. House of Representatives, Subcommittee on Space Science and Applications, Committee on Science and Technology, Ninety-seventh Congress, First Session, "Civil Land Remote Sensing System," December 1981.

[14] MacLeod, Norman H., "The Advanced Earth Resources Observations System (AEROS)—A Private Sector Civil Earth Observations Operational Program," American Science and Technology Corporation.

[15] U.S. Department of Commerce, National Oceanic and Atmospheric Administration (Michel T. Halbouty, Chairman, Land Remote Sensing Satellite Advisory Committee), Recommendations of the Land Remote Sensing Satellite Advisory Committee on the Subject of Commercialization of the Land and Weather Satellite Programs, November 18, 1982.

[16] U.S. Department of Defense (Major General Earl G. Peck, U.S.A.F.) and National Aeronautics and Space Administration, Goddard Space Flight Center, (Kathleen Charles), Reports of the Ad Hoc Government Interagency Panels on Civil Operational Remote Sensing Satellite Commercialization, November 10, 1982.

[17] ORI, "Report of the Private Sector Involvement Land Remote Sensing Satellite Workshop," prepared for the National Oceanic and Atmospheric Administration, Goddard Space Flight Center, National Aeronautics and Space Administration, under Contract No. NAS5-26264, held at Howard Johnson's Convention Center, Plainview, Long Island, New York, April 21-22, 1980.

[18] U.S. House of Representatives, Committee on Science and Technology, Ninety-seventh Congress, Second Session, Hearings before the Subcommittee on Space Science and Applications, "1983 NASA Authorization (A NOAA Landsat Authorization for 1983)," Vol. II, No. 98, February, 5, 9, 10, 12, 13, 15, 22, 23, 24, 25 and March 2, 3, 4, 1982.

[19] U.S. Department of Commerce (National Oceanic and Atmospheric Administration, Satellite Task Force), "Planning for a Civil Operational Land Remote Sensing Satellite System: A Discussion of Issues and Options," June 20, 1980.

[20] U.S. Department of Commerce (National Environmental Satellite, Data and Information Service, National Oceanic and Atmospheric Administration), "Transfer of the Civil Operational Earth Observation Satellites to the Private Sector," January 1983.

[21] U.S. Department of the Interior/Geological Survey, Studying the Earth from Space, 1977.

[22] National Conference of State Legislatures Remote Sensing Project, A Legislator's Guide to LANDSAT.

[23] Unknown Author, "Description of the LANDSAT-D Mission," Enclosure 3.

[24] General Electric, Landsat-D.

[25] FY1983 EROS Data Center Baseline LANDSAT Data Handling and Processing Activities, EROS Data Center.

[26] Earth Resources Benefit Cost Study, Earth Satellite Corp. with Booz-Allen Research Corp., 1974.

[27] The Economic Value of Remote Sensing of Earth Resources from Space, ECON, Inc., 1974.

[28] A Determination of the Value of Improved Performance in Sensors for an Earth Resources Satellite, ECON, Inc., 1980.

[29] Benefits, Risks and Costs of a Civilian High Resolution Multi-Spectral Satellite-Based Earth Resources Sensing System, Abt Association, 1981.

[30] A Summary of Worldwide LANDSAT Data Demand for Calendar Year 1981, Prepared for The LANDSAT Data Distribution Working Group, Washington, DC, October 28, 1982, Department of the Interior (EROS Data Center).

[31] OAO Corporation, "Analysis of the Private Market for Landsat Products and Applications," Final Report to Office of Space & Terrestrial Applications, NASA Headquarters, March 31, 1981.

[32] French Centre National d'Etudes Spatiales, "Satellite-Based Remote Sensing System."

[33] French Marketing Services of SPOT Satellite Network, Aviation Week and Space Technology, January 11, 1982.

[34] Spann, G. William, Nancy J. Hooper, Daniel J. Cotter, "An Analysis of User Requirements for Operational Land Satellite Data," presented at Fifteenth International Symposium on Remote Sensing of Environment, Ann Arbor, MI, May 1981.

[35] Natural Resource Information Systems Project, National Conference of State Legislatures (Paul A. Tessar, Loyola M. Caron and Jane Germano), "A Survey of State Applications of, and Investments in, LANDSAT Technology," May 1, 1981.

[36] Willard, Matthew R., "Understanding the LANDSAT Market in Developing Countries," Report No. 30, Contract NASW-3204, November 1980.

[37] Angenstein, Bruno, Willis Shapley and Eugene Skolnikoff, "Earth Information from Space by Remote Sensing," report prepared for Office of Science and Technology Policy, Executive Office of the President, June 1978.

[38] U.S. Department of Commerce, "Minutes of the Land Remote Sensing Satellite Advisory Committee Meeting," June 7-8, 1982.

[39] _______, "Minutes of the Land Remote Sensing Satellite Advisory Committee Meeting," November 18-19, 1982.

[40] House Committee on Science and Technology, Earth Resources Information System, Hearings, 95th Congress, 1st Session, June 21, 22 and 23, 1977.

[41] Senate Committee on Commerce, Science and Transportation, Earth Resources and Environmental Information System Act of 1977, Hearings, 95th Congress, 1st Session, May 24, 25; June 13, 14, 1977.

[42] House Committee on Science and Technology, Operational Civil Remote Sensing System, Hearings, 96th Congress, 2nd Session, June 24, 25; July 29, 1980.

[43] Senate Committee on Commerce, Science and Transportation, Civil Remote Sensing Satellite System, Hearings, 96th Congress, 2nd Session, June 26 and July 24, 1980.

[44] House Committee on Science and Technology, Worldwide Space Activities, September 1977, U.S. Government Printing Office, 1977, p. 607.

[45] ______, United States Civilian Space Programs 1958-1978, 97th Congress, 1st Session, 1981.

[46] National Academy of Sciences, Remote Sensing from Space: Prospects for Developing Countries, 1977.

APPENDIX A
ANALYSIS OF SATELLITE AND LAUNCH REQUIREMENTS

Satellite and launch requirements are determined by the demand for operational on-orbit sensors, the number of previous successful launches and the number of sensors that have failed due to random and wearout phenomena. Since failures occur randomly, the number of launch attempts as a function of time is not known deterministically, but must be described in terms of a probability distribution.

A simulation model* has been developed to assist with the programmatic evaluation of alternative approaches to establishing and maintaining a specific desired mix of operational sensors on spacecraft in geocentric orbit. The program enables the assessment of the effects of operational requirements and reliability (spacecraft support subsystems, sensors and transportation systems) on the time-phased costs of alternative approaches to satisfying mission requirements. The program is specifically designed to allow for the explicit consideration of reliability and cost uncertainties. In order to perform this evaluation, the launch systems and spacecraft (support systems** and sensors) are considered in detail from the points of view of reliability and cost. All costs are treated as uncertainty variables where ranges of possible values are considered as well as subjective estimates pertaining to the form of the uncertainty (the probability distribution) within the range. The input to the program consists primarily of a set of numbers which describes the demand for various operational sensors in orbit as a function of time, the mix of sensors available per spacecraft type, the transportation system to be used for each spacecraft type as a function of time, spacecraft subsystem, sensor and transportation system reliability, subsystem and sensor nonrecurring costs including cost spreading and explicit quantitative uncertainty assessments, spacecraft and transportation system costs including explicitly quantitative uncertainty assessments and cost learning rates. The output from the simulation program consists of a set of probability distributions associated with costs and events (i.e., number of launch attempts, etc.) as functions of time and the

---

*Greenberg J.S., "The Economic Implications of Uncertainty," Proceedings of the Annual Reliability and Maintainability Symposium, January 1976.

Greenberg, J.S. and G.A. Hazelrigg, "Methodology for Reliability-Cost-Risk Analysis of Satellite Networks," Journal of Spacecraft and Rockets, Vol. II, No. 9, September 1974.

**The group of support systems is frequently referred to as the spacecraft bus.

probability distribution of the present value of total recurring plus nonrecurring cost.

The reliability, uncertainty and risk assessment capability embodied in the simulation model allows for:

- Specification of the mix of operational sensors required in geocentric orbits as a function of time.
- Consideration of multiple spacecraft which are defined in terms of the reliability of the major support subsystems, the mix of on-board sensors and their reliability and spacecraft cost.
- Consideration of spacecraft subsystem and sensor failure models which allow for both random and wearout failures.
- Specification and consideration of multiple transportation systems which may consist of current or new expendables or the Space Shuttle. The transportation systems may also include (as necessary) orbit-to-orbit shuttles or propulsion modules (for example, Agena, Centaur, Space Tug, etc.). The propulsion modules may be expendable or reusable and may be used for placing spacecraft in orbit and retrieving spacecraft which fail and require replacement. The specification of the transportation systems include cost and reliability assessments. Reliability is considered at the major subsystem level.
- Specification of transportation systems to be utilized for placing different spacecraft into orbit as a function of time. Changing the specification of transportation system-spacecraft assignment as a function of time allows performance capability (such as allowable mission modes and reliability) and cost variations to be considered.
- Explicit consideration of multiple time periods thus allowing for annual costs to be established.
- Consideration of cost learning curves.
- All costs to be treated as uncertainty variables.

The simulation model, taking into account the required number of sensors as a function of time, number of operational sensors in orbit (as determined from spacecraft subsystem and sensor reliability characteristics) and spacecraft and launch costs, determines a near optimal mix of spacecraft launches as a function of time. Since the simulation is based upon Monte Carlo techniques, it is possible to establish the probability distributions of pertinent performance measures, which allows alternatives to be compared by considering both expected values of performance measures and the chance of variation (i.e., the risk) of the value of the measures. Specifically, the simulation model establishes the probability distributions of:

- Pertinent quantities by year (for example, number of launch attempts, number of spacecraft required, number of propulsion modules required, number of propulsion module refurbishments, etc.)

- Launch, spacecraft and total costs by spacecraft type and by year
- Bus and sensor nonrecurring costs
- Present value of recurring plus nonrecurring costs.

The sensors mix as a function of time, as established from Figure 3.1, was used as the sensor demand in a simulation analysis. The purpose of this analysis was to obtain insight into the number of spacecraft that should be procured in order to achieve a reasonable likelihood of continuity of service and the number of launch attempts that are likely to be required. The scenario described in Figure 3.1 was simulated or flown 1,000 times taking into account sensor and spacecraft support system random and wearout failures and the probability of major launch events being successful. The assumed demand for sensors is illustrated in Table A.1, the assumed sensor and subsystem reliabilities are indicated in Table A.2 and the launch vehicle (Delta) assumed reliabilities are indicated in Table A.3.

Since an expendable launch vehicle is utilized, the probability distribution of the number of launch attempts and the probability distribution of the number of spacecraft required are the same. These are summarized in Table A.4 as a function of time in terms of expected values and standard deviation.

The results of the simulation analysis indicate that a minimum of two spacecraft of each type will be required. The likelihood of continuous service with the purchase of two spacecraft is not high and a third spacecraft acquisition may be desirable.

TABLE A.1 ASSUMED SENSOR DEMAND (NO. OF REQUIRED SENSORS IN ORBIT)

SENSOR	FISCAL YEAR									
	'85		'87		'89		'91		'93	
MSS (80M)	1	1	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø
TM (30M)*	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
MLA (80M)	Ø	Ø	Ø	1	1	1	1	1	Ø	Ø
MLA (30M)	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1	1	1

*LAUNCH DOES NOT TAKE PLACE UPON FAILURE OF THE THEMATIC MAPPER.

TABLE A.2 ASSUMED SENSOR AND SUBSYSTEM RELIABILITY			
SENSOR/SUBSYSTEM	MEAN-TIME-TO-FAILURE (MTBF) (YEARS)	EXPECTED WEAROUT LIFE (YEARS)	VARIABILITY OF WEAROUT LIFE* (YEARS)
MSS	20	3	.5
TM	10	3	.5
MLA (80M)	25	5	.5
MLA (30M)	20	5	.5
POWER	30	5	.5
AVCS	30	5	.5
COMMUNICATIONS	30	5	.5
TT&C	30	5	.5
STRUCTURE	40	5	.5

*STANDARD DEVIATION OF WEAROUT LIFE.

TABLE A.3 LAUNCH RELATED RELIABILITIES	
ITEM	VALUE
• PROBABILITY OF SPACECRAFT FUNCTIONING PROPERLY WHEN PLACED IN FINAL ORBIT	0.95
• PROBABILITY OF BOOSTER SUCCESS	0.98
• PROBABILITY OF UPPER STAGE SUCCESS	0.98
• PROBABILITY OF ORBIT INJECTION SUCCESS	0.98

TABLE A.4 LAUNCH ATTEMPT STATISTICS

SPACECRAFT TYPE	FISCAL YEAR									
	'85		'87		'89		'91		'93	
LANDSAT E (MLA/80M)										
• EXPECTED NO. OF LAUNCH ATTEMPTS	Ø	Ø	Ø	1.20	0.19	0.22	0.25	0.48	Ø	Ø
• STD. DEV. OF NO. OF LAUNCH ATTEMPTS	Ø	Ø	Ø	0.84	0.44	0.47	0.50	0.61	Ø	Ø
LANDSAT F (MLA/30M)										
• EXPECTED NO. OF LAUNCH ATTEMPTS	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1.11	0.17	0.19
• STD. DEV. OF NO. OF LAUNCH ATTEMPTS	Ø	Ø	Ø	Ø	Ø	Ø	Ø	0.65	0.39	0.41

APPENDIX B

SUPPORTING DOCUMENTATION FOR INPUT DATA TO FINANCIAL ANALYSES

(1) Revenue - Supporting data is presented in Section 4.4, Market Forecast. In particular, reference is made to Figures 4.5 and 4.6. All data in these figures are in constant 1983 dollars. A 6 percent inflation rate was used to escalate the figures to 1985 and following years.

(2) Additional Federal Purchases - Corresponds to the annual subsidy that is required in order to achieve a desired annual return on assets. The subsidy is determined through an iteration process wherein the value is adjusted until the desired rate of return is achieved.

(3) Processing Cost/Scene-80M - Processing costs include those costs involved with the processing and handling of data from the moment of receipt at GSFC until its expedition to EDC. For MSS data, the primary activities are to make radiometric corrections, indicate the need for geometric corrections and record the data on high density tapes which will be used to transmit the data via satellite to EDC. For TM data, the functions performed at GSFC include receipt and recording of data on high density tapes (to remain at GSFC until transfer to federal archives) plus creation of photographic negatives and computer compatible tapes (CCTs) from these high density tapes, which will be mailed to EDC. The following determination of the processing cost/scene for 80 meter information products is based upon data provided by NOAA and is based upon processing 136 scenes daily.

Cost Category	Cost ($1.000)
Operations and Maintenance	7,148
High Density Tapes	215
Computer Compatible Tapes	20
Computer Tape Drive Performance Assessment	20
Photo Support	950
Total Annual Cost (FY83$)	8,353
Total Annual Cost (FY85$)	9,385

$$\text{Processing Cost/Scene (80M)} = \frac{\text{Total Annual Cost}}{\text{Scenes/Year}} \times \text{Cloud Factor} = \$270.30$$

with a cloud factor equal to 1.43. The cloud factor (see Note 6) multiplier is used to account for the fact that the financial model is driven by scenes sold and not scenes processed.

(4) Processing Cost/Scene-30M - The following determination of the processing cost/scene for 30 meter information products is based upon data provided by NOAA. The processing cost is the incremental cost of processing 50 30 meter scenes daily in imagery and ten scenes daily on tape, given that 136 MSS 80 meter scenes are being processed daily. (Refer to Note 3 for a description of what is included in the current processing costs.)

Cost Category	Cost ($1,000)
Total HDT & CCT Tape & Handling	950
Photo Support	2,030
Ground Segement Operations & Maintenance	2,652
Total Annual Cost (FY83$)	5,632
Total Annual Cost (FY85$)	6,328

$$\text{Processing Cost/Scene (30M)} = \frac{\text{Total Annual Cost}}{\text{Scenes/Year}} \times \text{Cloud Factor} = \$495.80$$

with a cloud factor equal to 1.43. The cloud factor (see Note 6) multiplier is used to account for the fact that the financial model is driven by scenes sold and not scenes processed. The above cost per scene is based upon 18,250 scenes per year.

(5) Processing Learning Factor - It is assumed that processing cost for repetitive functions will tend to decrease with time because of learning. A typical learning equation, as indicated below, has been utilized to predict future cost reductions.

$$L(I) = \frac{\text{Cost in Year I}}{\text{Cost Base}} = I^{[\log_{10}(\text{CALR}) - 2.0]/.301}$$

The learning factor, L(I), indicates the cost in the I^{th} year relative to the current or base cost. The assumption is that costs are reduced by 100-CALR percent every time the number of years doubles. CALR represents the cumulative average learning rate (%). The processing learning factor is based upon a 90 percent learning curve. The specific values utilized are presented below along with learning factors based upon other learning rates.

FISCAL YEAR	LEARNING FACTOR, L(I)			
	LEARNING RATE, CALR			
	95%	90%	85%	80%
'85	1.00	1.00	1.00	1.00
'86	.95	.90	.85	.80
'87	.92	.85	.77	.70
'88	.90	.81	.72	.64
'89	.89	.78	.69	.60
'90	.88	.76	.66	.56
'91	.87	.74	.63	.53
'92	.86	.73	.61	.51
'93	.85	.72	.60	.49
'94	.84	.70	.58	.48

(6) Processing/Sales Factor - This factor accounts for the difference between scenes archived and scenes sold, since archived scenes may be sold more than once while other scenes may not be sold at all.

$$\text{Processing/Sales Factor} = \frac{\text{Total Scenes Received at EDC in FY82}}{\text{Total Scenes Sold in FY82 x Cloud Factor}}$$

The cloud factor represents an adjustment since scenes with significant cloud cover are handled in a somewhat different manner. Scenes received at Goddard Space Flight Center are flagged during processing to high density tape if the cloud cover is great enough to render the scene obscure. Although these scenes are currently processed for archiving at EDC, it is assumed that a decision will be made not to further process these obscure scenes, which are estimated at about 30 percent of the total. Therefore, the number of scenes processed (at GSFC) equals the number of scenes transmitted from White Sands, but scenes archived* at EDC will be reduced from scenes processed by a "cloud factor." It should be noted that:

No. of Scenes Transmitted from White Sands = No. of Scenes Processed at GSFC
No. of Scenes Archived = No. of Scenes Processed/CF
No. of Scenes Sold = No. of Scenes Processed/(CF x AF)

CF = Cloud Factor = 1.43
AF = Archival or Processing/Sales Factor = 0.52

---

*Scenes with too much cloud cover will be recorded on the high density tape (HDT) and retained in the archives, but it is assumed that further processing, such as producing a film master, will not be done.

The cloud factor of 1.43 is based upon 30 "bad" scenes out of 100 scenes (i.e., 70 "good" scenes). Therefore, to get 70 good scenes it is necessary to process 100 scenes or 1.43 times the 70 scenes. To go from scenes processed to good scenes it is necessary to divide by 1.43.

(7) Archival Cost/Scene-80M - Archiving costs are costs incurred in receiving data at EDC, processing data into format required for archiving and maintaining the archives. In the case of MSS data, after the receipt of data from GSFC it is recorded on high density tapes. Scenes from the high density tape are processed to film images which are sent to the photo lab and a master made. The high density tapes and film masters are then archived.

When EDC receives a TM film image from GSFC it makes a master film image for storage in the archives. The CCT it receives is stored in the archive after a copy is made for the client. TM archiving costs include the cost of making the film master plus cost of receiving and cataloging the data and maintaining the database.

Cost Category	Cost ($1,000)
Data Receipt & Catalog	669
Data Processing & Archive Creation	1,358
Archive Database Maintenance	148
Total Annual Cost (FY83$)	2,175
Total Annual Cost (FY85$)	2,445

Archiving Cost/Scene (80M) = $49.70
(based on archiving 49,275 scenes/year)

(8) Archival Cost/Scene-30M - Since data is not currently available on all of the TM archiving costs, approximations are necessary and are based upon scaling of MSS costs as follows. (Refer to Note 7 for what is included in archiving costs.) From Note 7, the average cost of receipt and catalog ($669,000) and archive database maintenance ($148,000) is $817,000 for MSS scenes. This reduces to $16.60 per scene. Since the number of items (film images or computer compatible tapes) should be about 1.75 times greater (TM has seven spectral bands whereas the MSS has four spectral bands) than produced for an MSS scene, it is assumed that the cost of receipt, cataloging and archive database maintenance for TM data is 1.75 times that of MSS data or $29.00 per scene. An approximate cost of making a working film master for storage

in the archive is $79.40 per TM scene. Therefore, the average cost to archive a TM scene is $108.40 FY83$ or $121.80 FY85$.

(9) Archival Learning Factor - A learning rate of 90 percent has been assumed. See Note 5 for details.

(10) Cost of Sales/Unit - Sales costs are those costs involved in reproducing scenes for sale to the public, and distributing the scenes. Film images are made from the film master which is stored in the archives. CCTs are made from the archived high density tape in the case of MSS data, and from the CCTs received from GSFC for TM data.

MSS estimated cost for reproduction and sale of approximately 78,750 film scenes is as follows:

	Cost ($1,000)
Product Generation & Dissemination	1,480
Customer Interface	645
	2,125

This results in MSS film cost of $27.00 FY83$ or $30.30 FY85$ per scene.

MSS estimated cost for reproduction and sale of approximately 4000 CCT scenes is as follows:

	Cost ($1,000)
Product Generation & Dissmenination	435
Customer Interface	215
	650

This results in MSS tape cost of $162.50 FY83$ or $182.60 FY85$ per scene.

TM costs are estimated to be 7/4 (the ratio of TM spectral bands to MSS spectral bands) times the MSS costs. Therefore, TM film and tape costs are estimated as $53.10 and $319.60 FY85$ per scene, respectively.

(11) Cost of Sales Learning Factor - A learning rate of 90 percent has been assumed. See Note 5 for details.

(12) Indirect Labor - Indirect labor costs are those costs that are independent of the number of scenes processed and include management, spacecraft maneuvering and positioning, and building operations and maintenance. These costs are as follows:

Cost Category	Cost ($1,000)
Building Operations & Maint.	1,651
Spacecraft Orbital Element	120
NOAA Management	2,500

Communications-Telex Link to Foreign Stations	110
Building 28 Local Communication	45
NOAA Administrative Costs at EDC	32
Total Annual Cost (FY83$)	4,458
Total Annual Cost (FY85$)	5,009

(13) R&D - It is assumed that NASA will continue to undertake research and development relating to new sensors and related technologies and new information extraction techniques. It is assumed that the government R&D expenditures will be on the order of $10 million per year. It is assumed that a private sector business venture (Scenario 3) will undertake R&D to improve computational efficiency and information products. It is estimated that the cost (fully burdened) of a professional involved in the R&D is $90,000 per year. It is assumed that the R&D organization should include approximately ten professionals ($900,000/year) and will increase as sales build over time and achieve a level of 4 percent of sales. Therefore, R&D costs will be $900,000 per year or 4 percent of sales, whichever is greater.

(14) Marketing, Advertising & Promotion - Marketing, advertising and promotion includes customer interface, market development and applications engineering as well as the other sales-oriented functions. It is assumed that the average cost per salesperson is $158,000 ($45,000 in compensation multiplied by 2.5 for overhead and G&A, plus $45,000 in expenses). It is assumed that there are 1.5 professional persons supporting each salesperson at a cost of $75,000-$85,000 per year. Therefore, the effective cost per salesperson is $278,000 per year.

As a minimum, it is assumed that one salesperson is required for foreign sales (mainly keeping and getting new ground stations), one salesperson is required for federal sales, two salespersons are required for industrial and state/local government/academic sales. Therefore a minimum market organization is as follows:

4 salespersons 6 professional support	$1,110,000 per year
1 management ($65,000 x 2.5)	$ 160,000 per year
	$1,270,000 per year

it is assumed that this marketing organization will increase with sales reaching an expenditure level of 5 percent of sales. Therefore, Marketing, Advertising & Promotion Costs will be $1,425,000 FY85$ per year or 5 percent of sales, whichever is greater.

(15) Communications Costs (TDRSS) - This represents the cost of transmitting data through the Tracking Data Relay Satellite System from LANDSAT to the White Sands ground receiving station. Charges are based on a per minute rate depending on type of access.

A typical transmission lasts approximately 26 minutes and consists of a mix of the different types of access. This occurs approximately 20 times per day. During each 26 minute interval seven MSS and five TM scenes (on average) are transmitted. The average cost* for a typical transmission is

Access	Time		Cost per Minute	Total Cost Per Event
Single Access	14 minutes	x	$91	$1,274
Multiple Access Forward	2 minutes	x	$20	40
Multiple Access Return	10 minutes	x	$ 6	60
				$1,374

Therefore,

$1,374 = 7 x cost of transmitting MSS scene + 5 x cost of transmitting TM scene

It is estimated that the cost to transmit a TM scene will be 5.67 times that of an MSS scene.** The cost to transmit an MSS scene is therefore $38.90 (FY83$) or $43.70 (FY85$). This must be multiplied by the cloud factor (refer to Note 6) so that the total cost per MSS scene is $62.50 (FY85$). Similarly, the total cost (including the cloud factor) for transmitting a TM scene is $354.10 (FY85$).

*The analysis is based upon the use of rates for nongovernmental users rather than rates that will be charged to NOAA, because the former is likely to be more representative of the true costs of using TDRSS.

**TM data is trar[illegible]ted at the rate of 85 megabits per second and MSS data at the rate of 1[illegible]gabits per second. Both require 24 seconds for a scene to arrive at White Sands (net of any time that the satellite isn't collecting usable data).

(16) Communications Costs (DOMSAT) - This represents the cost of transmitting data via the Domestic Communications Satellite System. Both TM and MSS data are transmitted from White Sands to GSFC using the DOMSAT 50 megabit link. MSS data is sent to EDC from GSFC on the DOMSAT 20 megabit link (TM data is mailed).

The cost of using the DOMSAT 50 megabit link is \$3.50/minute. Including set-up and other overhead time,* it takes an estimated 48 seconds for an MSS scene and 72 seconds for a TM scene to arrive at GSFC. Therefore, MSS DOMSAT cost is:

MSS DOMSAT Cost = 0.8 minutes/scene x \$3.5/min = \$2.80/scene (FY83\$)

It is assumed that the cost to transmit an MSS scene to EDC from GSFC is approximately the same as transmitting from White Sands to GSFC, \$2.80. In addition, an inventory tape (GHIT) is communicated by phone to EDC and this costs about \$.90 per scene; therefore total cost to send an MSS scene from White Sands to EDC is \$6.50 (FY83\$) or \$7.30 (FY85\$). This must be multiplied by the cloud factor (refer to Note 6) so that the total cost per MSS scene is \$10.40.

The cost to send a TM scene from White Sands to GSFC is:

TM DOMSAT Cost = 1.2 minutes x \$3.5/min = \$4.20 (FY83\$).

Adjusting to FY85 and multiplying by the cloud facter yields \$6.70 per scene (FY85\$).

(17) TDRSS Lease Costs (Annual) - This represents the lease costs associated with the Tracking Data Relay Satellite System which are independent of usage. Since TDRSS costs have been assumed to be directly proportional to scenes sold, this fixed annual cost has been set equal to zero.

(18) DOMSAT Lease Costs (Annual) - This represents the lease costs associated with the DOMSAT communication system which are independent of usage. Since DOMSAT costs have been assumed to be directly proportional to scenes sold, this fixed annual cost has been set equal to zero.

---

*Time during which the system is turned on but not collecting useful data.

(19) <u>Lease Costs (LANDSAT D and D')</u> - It is assumed that for Scenarios 3 and 5, LANDSAT D and D' are transferred to the private sector business venture. Different recoupment payment policies are considered. Lease costs are zero for Scenarios 1, 2 and 4 since it is assumed that transfer of these assets is through nonlease arrangements.

(20) <u>Lease Costs (Ground Facilities-GSFC, EDC, White Sands and Nongovernment)</u> It is assumed that, initially, ground facility assets are leased from the government (operating leases with no transfer of title). It is assumed that in 1989 all facilities are consolidated at White Sands at which time leases are entered into with nongovernment organizations. It is assumed that the lease policy is to recoup a fraction (0 to 1.0) of the book value of the leased asset through an annuity such that the present value of the annuity is equal to δ x Book Value where δ is the fraction of the book value recouped and book value, BV, is given by

$$BV = \text{Acquisition Cost} \times \left[\frac{\text{Useful Life - Years in Service}}{\text{Useful Life}}\right].$$

And the value of the annual annuity payment, A, is given by

$$A = \frac{\delta \times BV \times r/100}{1-1/(1+r/100)^M}$$

Where r = cost of capital

M = number of payments for establishing lease rate.

The following schedule is assumed:

FY

		'86		'88		'90		'92		'94
GSFC	L_{GSFC}	L_{GSFC}	L_{GSFC}	L_{GSFC}	-	-	-	-	-	-
EDC	L_{EDC}	L_{EDC}	L_{EDC}	L_{EDC}	-	-	-	-	-	-
WHITE SANDS	L_{WS}	L_{WS}	L_{WS}	L_{WS}	L_{WS}	L_{WS}	L_{WS}	L_{WS}	L_{WS}	L_{WS}
NONGOVERNMENT	-	-	-	-	L_{NG}	L_{NG}	L_{NG}	L_{NG}	L_{NG}	L_{NG}

The venture initially leases facilities (GSFC processing facilities, EDC processing and archiving facilities, and White Sands tracking and communications facilities) from the government. These lease rates are L_{GSFC}, L_{EDC} and L_{WS}. After consolidation the venture leases similar equipment to be located at White Sands. It is assumed that the lease rate of White Sands equipment is small relative to that at GSFC and EDC. The lease rate of the equipment to be acquired and located at White Sands is approximated as follows:

$$L_{NG} = (L_{GSFC} + L_{EDC}) \times E \times L - L'_{GSFC}$$

where E is an efficiency factor relating to the consolidation of the EDC and GSFC data processing facilities, L is a learning factor (it is assumed that both processing algorithms and equipment improve with time) (refer to Note 5 for a discussion of learning factors) and L'_{GSFC} is the effective lease rate paid on equipment not required at the combined facility.

A 90 percent learning rate is assumed. Therefore L = 0.78. It is assumed that the cost of computers to the government has a profit built in for the private sector. When the commercial entity leases a computer from the private sector there is also a profit for the private sector. It is assumed that these are basically the same on a percentage basis. NOAA has estimated equipment costs at GSFC to be approximately $101 million and EDC has estimated equipment cost associated with LANDSAT at EDC to be approximately $14 million.

The following lease rates have been estimated and used in the analysis:

$$BV(GSFC) = \$101 \text{ million} \times \left[\frac{\text{8 yrs. useful life - 2 yrs. prior to start of lease}}{\text{8 yrs. useful life}}\right]$$

$$BV(EDC) = \$14 \text{ million} \times \left[\frac{\text{8 yrs. useful life - 4 yrs. prior to start of lease}}{\text{8 yrs. useful life}}\right]$$

At a cost of capital of 10 percent,

$$L_{GSFC} = 101 \times \left(\frac{8-2}{8}\right) \times .10/[1-1/1.10)^4] = \$23.9 \text{ million}$$

$$L_{EDC} = 14 \times \left(\frac{8-4}{8}\right) \times .10/[1-(1/1.10)^4] = \$2.2 \text{ million}$$

$$L_{NG} = (23.9 + 2.2) \times .78 \times .90 - 2 = \$16.3 \text{ million}$$

where E = .90 and L'_{GSFC} = \$2 million.

Since the lease at White Sands starts in 1989, L_{NG} must be adjusted from FY83 to FY89 dollars by multiplying by $(1.06)^6$. The result is

$$L_{NG} = \$23.12 \text{ million FY89\$ in FY89 and beyond.}$$

(21) Assets: Ground Segment - It is assumed that all ground segment equipment is leased. Therefore the asset value of the ground equipment is zero.

(22) Space Segment - The following is a summary of the launch costs and the availability of launch vehicles. LANDSAT D consists of the NASA standard Multi-Mission Modular Spacecraft (MMS) and a mission-unique sensor module. LANDSAT D was launched into a nominal 425 n mi sun synchronous polar orbit by a Delta 3920 launch vehicle from the U.S. Western Test Range.

The MMS is designed to be compatible for launch from both the Delta and the Space Shuttle Orbiter. However, the long (14' length) and narrow (7' width) configuration of LANDSAT D is not optimum from a cost standpoint for Shuttle launch. As the MMS is designed for compatibility with the Delta and Shuttle, it will also be compatible with the Ariane launch vehicle. These three launch vehicles constitute the primary candidates for further launches of LANDSAT spacecraft in the configuration of LANDSAT D. Other expendable launch vehicles such as proposed commercial versions of the Atlas-Centaur or Titan could also be used; however, the use of these launch vehicles would necessitate design modifications in the spacecraft. Moreover, there are no plans at the present to achieve a near polar orbit capability with the commercial Titan.

For the purpose of obtaining launch cost information it was assumed that the future LANDSAT spacecraft would be similar in physical characteristics and orbit requirements to LANDSAT D. Launch dates of January 1987, January 1991 and January 1996 were used to solicit launch cost information from the operators of the Ariane, Delta and Shuttle.

The results of these enquiries indicate that the launch vehicle area is in a state of flux and it is difficult to obtain costs that can be used with a great deal of certainty for the prospective launches. At the present time the Delta Program Office does not plan to continue to supply the Delta launch vehicle after its use for two GOES missions in FY86. In response to this enquiry,

NASA quoted a cost of about $35 million in FY85 dollars for a Delta launch prior to the termination of the program in FY86. NASA was unable to quote costs beyond this date because of the planned termination of the Delta launch vehicle. Informal discussions of the proposed launches with NASA Shuttle marketing personnel indicate that NASA has not yet formulated a pricing policy for WTR launches. Moreover, the published Shuttle pricing policy does not extend beyond FY88. In the absence of a pricing policy that extends to the time period of interest for WTR, it was suggested that the price of a Shuttle launch from WTR would be about the same as that from ETR. Because of the spacecraft configuration, weight and orbit requirements, LANDSAT would probably require a dedicated Shuttle launch. The suggested price for a dedicated Shuttle launch from WTR was about $40 million in 1975 dollars. Discussions with Arianespace indicate that the LANDSAT launch would require the Ariane 40 vehicle. Funding for the development of the Ariane 4 series of launch vehicles was approved in 1982 and it is expected to be operational in 1986. Discussions with Arianespace indicate that the budgetary price for an Ariane 40 launch is $60 million to $65 million in 1982 dollars.

On the basis of this brief survey, it is clear that the Shuttle will be supported from WTR. On the other hand, it is not clear that any of the current U.S. expendable launch vehicles will be supported from WTR post FY86. One possible scenario for this time period might postulate competition between two or more U.S. launch vehicles and perhaps the Ariane. Although NASA now indicates that it will not support the Delta in the post FY86 time period; it is possible that competition will drive the price of competing launch systems to that quoted for the Delta, or that a commercial version of the Delta will be developed as one of the competitors. In view of the clear price advantage of the Delta 3920, the price of the Delta 3920 was used as the basis for estimating launch costs for the prospective LANDSAT launches.

(23) <u>Assets: Space Equipment</u> - The space equipment assets include LANDSAT D, D', E, E', F, F', G and G'. These are procured at different points on time with both D and D' having already been procured.

Data from GSFC indicates a total cost of $361 million for D and D'. It is assumed that this cost is divided evenly between D and D'. Therefore

$$\text{LANDSAT D Book Value} = [180 + 35] \times \left[\frac{\text{3 yr. life-2 yrs. used by '85}}{\text{3 yrs. life}}\right]$$
$$= \$71.7 \text{ million}$$

$$\text{LANDSAT D' Book Value} = [180 + 35 + 33] \times [1]$$
$$= \$248 \text{ million}$$

where it has been assumed that the Delta launch cost is $35 million and D' storage cost is $33 million.

The following cost estimates (in millions of dollars) have been made for the post-D' satellites:

	LANDSAT			
	E	E'	F	F'
SPACECRAFT	$40\times(1.06)^3$	$40\times(1.06)^3$	$40\times(1.06)^6$	$40\times(1.06)^6$
MLA (80M)	$50\times(1.06)^3$	$10\times(1.06)^3$		
MLA (30M)			$75\times(1.06)^6$	
INTEGRATION/TEST	$20\times(1.06)^3$		$20\times(1.06)^6$	$30\times(1.06)^5$
LAUNCH COST	$35\times(1.06)^3$	$35\times(1.06)^3$	$35\times(1.06)^6$	$35\times(1.06)^6$
TOTAL COST (10^6\$)	172(FY86$)	101(FY86$)	241(FY89$)	149(FY89$)

Since costs are spread over time, the above table is an approximation but deemed acceptable.

LANDSAT E is estimated as a two and one-half to three year program with expenditures of 20 percent, 50 percent and 30 percent in each of the years (as per GSFC). LANDSAT F is estimated as a five year program with expenditures of 15 percent, 20 percent, 30 percent, 20 percent and 15 percent in each of the years (as per GSFC). These values have been adjusted to reflect the launch cost. Thus, as indicated by the "Construction In Progress," the cumulative expenditures add up to 100 percent when launch occurs.

Without knowledge of what G and G' will comprise, annual expenditures have been estimated and are based upon the previous history of expenditures.

(24) Cash Requirement in Days - It is assumed that 15 days of cash are required as measured against total revenue (i.e., 15/365 x total revenue).

(25) A/R Requirement in Days - It is assumed that accounts receivable are an average of 60 days old. Average accounts receivable balance is equal to approximately 1/6 of revenue (i.e., 60/365 x revenue).

(26) Current Liability Requirement in Days - Current liabilities are assumed to be paid within 30 days.

(27) Contributed Capital - Contributed capital for the private sector financial projections are assumed to be an initial capitalization of $75 million. The capital investment remains constant over the ten year period.

(28) Cost of Borrowing - Long-term borrowing rates are assumed to be 11 percent over the ten year projection. The 11 percent borrowing rate is predicated upon the 6 percent inflation rate used in the projection. Although current long-term borrowing rates are currently higher than 11 percent, it is assumed that by 1985, the first year of the projection, that long-term rates will be in the 10-12 percent range.

(29) Federal and State Tax Rate - A 51 percent combined federal and state tax rate has been used to calculate provision for taxes on net income (46 percent federal, 5 percent state).

(30) Investment Tax Credit Base - Property qualifying for the investment tax credit is reflected for calculation purposes. All space segment property both fully constructed and in process during the year are included in the investment tax credit base.

(31) Investment Tax Credit Rate - A 10 percent investment tax credit has been applied to all qualified property. For tax purposes, a five year ACRS life has been assumed. For depreciation purposes, a 5 percent reduction to the basis of all depreciable property has been applied.

(32) Equity Participation by the U.S. Government - It is assumed that for the legislatively-chartered, privately-owned corporation scenario, the U.S. government's equity participation will be 33 percent. The percentage participation used is arbitrary, and is used for illustrative purposes.

(33) Research and Development Tax Credit Rate - A 15 percent R&D tax credit rate has been assumed although the precise rate may vary. The exact rate applied will be dependent upon the nature of the R&D, average annual expenditures and type of R&D (in-house research expenses vs. contract research expenses).

(34) Royalties—Base Fee - This amount reflects the minimum guaranteed royalty or licensing fee paid to the U.S. government under the private sector marketing scenario. A minimum base fee of $33.5 million for the exclusive marketing rights to LANDSAT data is assumed.

(35) Royalties as a Percentage of Sales - It is assumed that a minimum royalty of 80 percent of LANDSAT sales would be paid to the U.S. government if 80 percent of sales exceed the guaranteed minimum of $33.5 million.

(36) Government R&D Expenditures - Current government R&D expenditures relating to the current land remote sensing system are not currently accumulated in a manner conducive to used for projection purposes. A $10 million per year R&D expenditure by the U.S. government has been used for projection purposes in all scenarios other than planned phase-out.

(37) Direct Costs - The equations used for the computation of processing, archiving and sales costs are as follows:

$$\text{Processing Cost (I)} = [MTS(I) + MFS(I)] \times K \times P_{MSS}(I) + [TTS(I) + TFS(I)] \times K \times P_{TM}(I) + ID(I)$$

$$\text{Archival Cost (i)} = [(MTS(I) + MFS(I)) \times A_{MSS}(I) + (TTS(I) + TFS(I)) \times A_{TM}(I)] \times AF \times L_A(I)$$

$$\text{Sales Cost (I)} = [MTS(I) \times S_{MSST}(I) + MFS(I) \times S_{MSSF}(I) + TTS(I) \times S_{TMT}(I) + TFS(I) \times S_{TMF}(I)] \times L_S(I) + [MTS(I) + MFS(I) + TTS(I) + TFS(I)] \times CI(I)$$

$K = CF \times AF$

where

$MFS(I)$	=	Number of MSS film scenes sold in year I
$MTS(I)$	=	Number of MSS tape scenes sold in year I
$TFS(I)$	=	Number of TM film scenes sold in year I
$TTS(I)$	=	Number of TM tape scenes sold in year I
$P_{MSS}(I)$	=	Per scene cost to process MSS data at Goddard
$P_{TM}(I)$	=	Per scene cost to process TM data at Goddard
$ID(I)$	=	Indirect costs associated with processing MSS and TM data at Goddard
$A_{MSS}(I)$	=	Per scene cost to archive MSS data at EDC
$A_{TM}(I)$	=	Per scene cost to archive TM data at EDC
$L_A(I)$	=	Learning rate associated with the archiving procedure
$S_{MSST}(I)$	=	Per scene cost of reproducing for sale an MSS tape scene
$S_{MSSF}(I)$	=	Per scene cost of reproducing for sale an MSS film scene
$S_{TMT}(I)$	=	Per scene cost of reproducing for sale a TM tape scene

$S_{TMT}(I)$ = Per scene cost of reproducing for sale a TM film scene

$L_S(I)$ = Learning rate associated with reproducing for sale

CI = Per scene cost of customer interface

AF = Archival factor (see Note 6)

CF = Cloud factor (see Note 6)

(38) Communicatons Cost - The equations used for the computation of TDRSS and COMSAT costs are as follows:

$$\text{TDRSS Cost (I)} = [\text{MFS(I)} + \text{MTS(I)}] \times K \times T_{MSS}(I) + [\text{TFS(I)} + \text{TTS(I)}] \times K \times T_{TM}(I)$$

$$\text{DOMSAT Cost (I)} = [\text{MFS(I)} + \text{MTS(I)}] \times K \times D_{MSS}(I) + [\text{TFS(I)} + \text{TTS(I)}] \times K \times D_{TM}(I)$$

where

$T_{MSS}(I)$ = Per scene cost to transmit MSS via TDRSS (satellite to White Sands)

$T_{TM}(I)$ = Per scene cost to transmit TM via TDRSS

$D_{MSS}(I)$ = Per scene cost to transmit MSS via DOMSAT (from White Sands to Goddard, and from Goddard to EDC)

$D_{TM}(I)$ = Per scene cost to transmit TM via DOMSAT (White Sands to Goddard)

and other terms are as defined in Note 37.